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THE NATIONAL GEOGRAPHIC MAGAZINE

AUGUST, 1912

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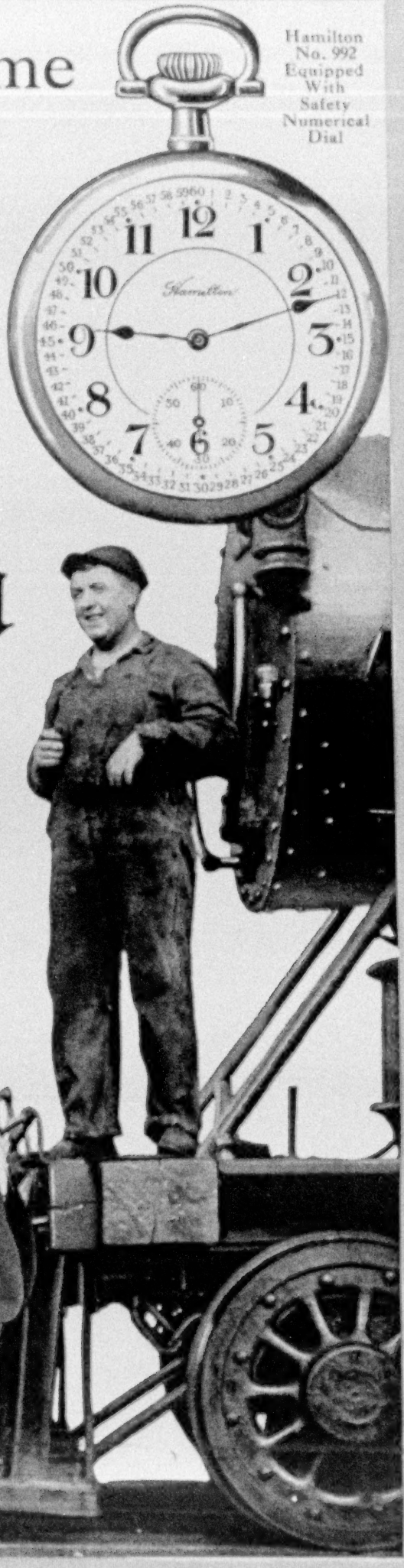

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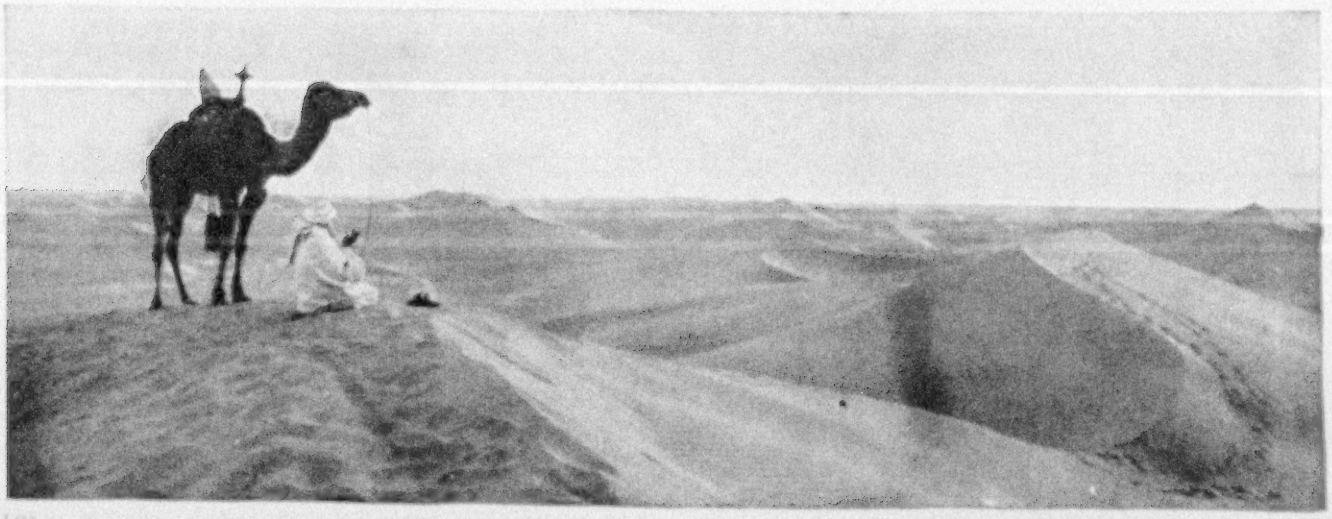

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VOL. XXIII, No. 8 WASHINGTON AUGUST, 1912

THE NATIONAL GEOGRAPHIC MAGAZINE

NOTES ABOUT ANTS AND THEIR RESEMBLANCE TO MAN

By William Morton Wheeler, Ph. D.
Professor of Economic Entomology in Harvard University

Dr. Wheeler is the author of an unusually entertaining book, "Ants, Their Structure, Development, and Behavior," published by the Columbia University Press. The volume contains 650 pages and several hundred illustrations, and is probably the most scholarly and suggestive work on the subject that has been published. The pictures illustrating this article are from the above book.

IT IS sometimes profitable to turn away from the consideration of the social and economic problems, which so constantly beset us, to a study of the social insects and their methods of solving the problems which they, too, have had to face during their long and strenuous evolution.

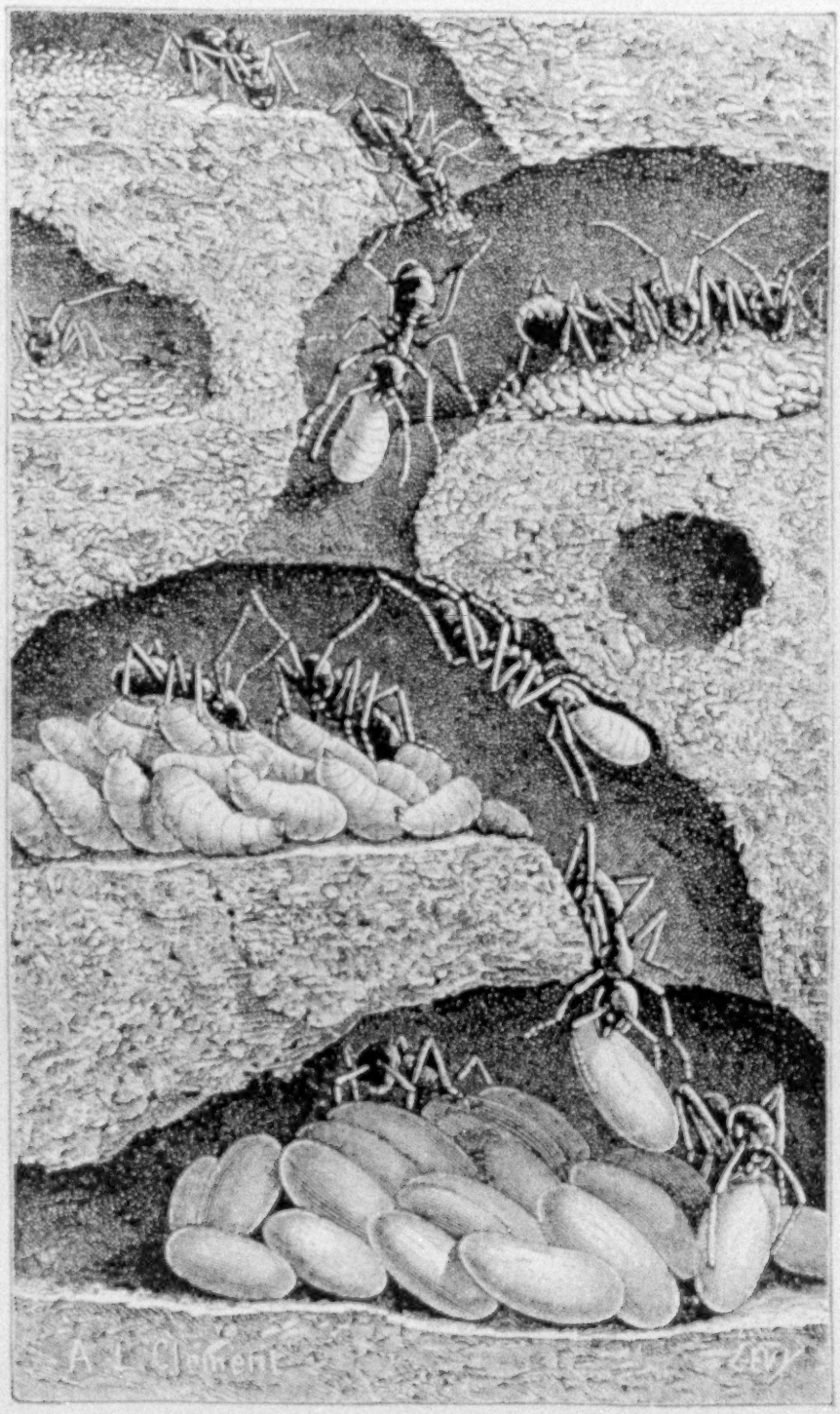
Though in most respects man and the insect differ enormously, both nevertheless display some remarkable convergent similarities. They are the only two successful and dominant animal types of the present age, and, so far as they are social, not only have had to encounter the same obstacles, but have learned to overcome many of them in the same manner.

The social insects, however, have been more successful than man in organizing stable communities, because they have frankly trusted and followed their instincts and have therefore carried their social organization to its logical, or perhaps we had better say instinctive, conclusion, whereas man's intellectual processes and the ideals and dissentions to which they give birth forever prevent a definitive solution of economic problems and keep him in a state of active and ceaseless evolution.

We naturally find, therefore, that the stable and well-regulated insect societies, which have "neither guide, overseer, nor ruler," have always aroused the admiration of those who long for a rigid communistic control of human society, while the individualist turns away from them with a feeling akin to horror.

THREE GREAT PROBLEMS OF EXISTENCE

It is well known that three great problems must be solved by every organism that would survive in the struggle for existence; first, how to obtain a sufficient quantity of the right kind of food; second, how to reproduce its kind and bring up its offspring, and, third, how to protect itself and its offspring from the injurious effects of both the lifeless and the living environment. And although all animals are constantly impelled to the solution of these problems by the primal instincts of hunger, love, and fear, the solution is often extremely difficult. And it is especially difficult in the social and colonial animals, because these must en-



INTERIOR OF AN ANT NEST OR FORMICARY (AFTER ERNEST ANDRÉ)

Showing the arrangement of the chambers and galleries and the ants' method of classifying the brood according to stages. The lowermost chamber contains only cocoons (pupæ), the next above mature larvæ, while the young larvæ and eggs are in the superficial chambers.

ter into severe competition not only with other organisms, but also with the members of their own species, to whom they are, moreover, bound by indissoluble ties.

There are two main groups of social insects, the termites and the social Hymenoptera, the latter embracing three minor groups, the social wasps, the social bees, and the ants. It is more than probable that social habits were developed independently in all four of these groups, and that such resemblances as they exhibit are due more to what biologists call convergence than to blood relationship.

Ants are to be found everywhere, from the arctic regions to the tropics, from timberline on the loftiest mountains to the shifting sands of the dunes and seashores, and from the dampest forests to the driest deserts. Not only do they outnumber in individuals all other terrestrial animals, but their colonies even in very circumscribed localities often defy enumeration. Their colonies are, moreover, remarkably stable, sometimes outlasting a generation of men. Such stability is, of course, due to the longevity of the individual ants, since worker ants are known to live from four to seven and queens from 13 to 15 years. In all these respects the other social insects are decidedly inferior.

A GREAT PRODUCER OF SPECIES

Not only are the colonies of the wasps and bumblebees of rather rare occurrence, but they are merely annual growths. The honey-bees, too, are very short-lived, the workers living only a few weeks or months, the queens but a few years. The termites, though perhaps longer-lived than the bees and wasps, are practically confined to very definite localities in the tropics. Only a few of the species have been able to extend their range into temperate regions.

Thus unquestionably the most successful and dominant of all these groups is the ants, for these have produced the greatest number of species, have occupied all parts of the earth, except the very tops of the high mountains and the cold arctic and antarctic regions, with untold multitudes of individuals, and have developed the most intimate and complicated rela-

tionships to other insects and the vegetation of the planet. It is therefore particularly instructive to study the methods whereby the ants as social insects have solved the problems of nutrition, reproduction, and protection.

The ant colony or society may be regarded as an organism which, like the individual insects of which it consists, grows and develops to a fixed adult size, and the size to which it grows is characteristic of the species, just as is the size of any individual. Some ants always form diminutive colonies of only a few dozen individuals, whereas the colonies of other species, when mature, may comprise thousands or hundreds of thousands. The growth of these colonies obviously depends on the quantity and quality of the available food supply and on its distribution for immediate consumption, or its storage for the future use of the colony.

THE INTRICATE PROCESS OF FOOD CONSERVATION

Ants feed on a great variety of substances, but in all cases only the liquid portions of the food are taken into the alimentary tract. If the food is solid, minute particles of it are rasped off by means of the tongue and pressed into a small pocket in the floor of the mouth. The juices expressed from the mass are then sucked back through the gullet into a dilated portion of the alimentary tract, the crop, and the useless pellet is spit out.

The crop is very distensible, but thin-walled and lined with a layer of chitin, which is impenetrable to the liquid contents, so that none of the food, so long as it is stored in this receptacle, can be absorbed or digested. The crop is closed behind by a complicated valve, which separates it from a short, bag-like stomach, the walls of which have a permeable lining, so that it and the succeeding portions of the alimentary tract, the intestine, are able to digest and absorb any food which may be permitted to enter them through the valve.

The crop and true stomach have been called respectively the "social" and "individual" stomachs, because the liquid food stored in the former is in great part distributed by regurgitation to other ants,

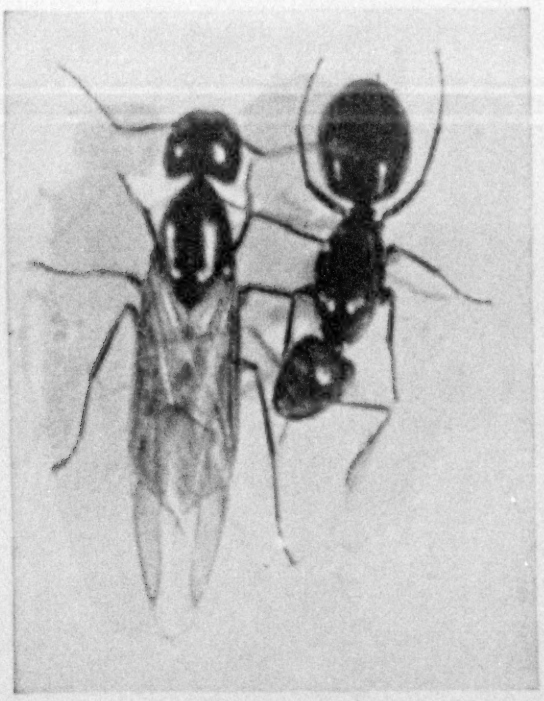


Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

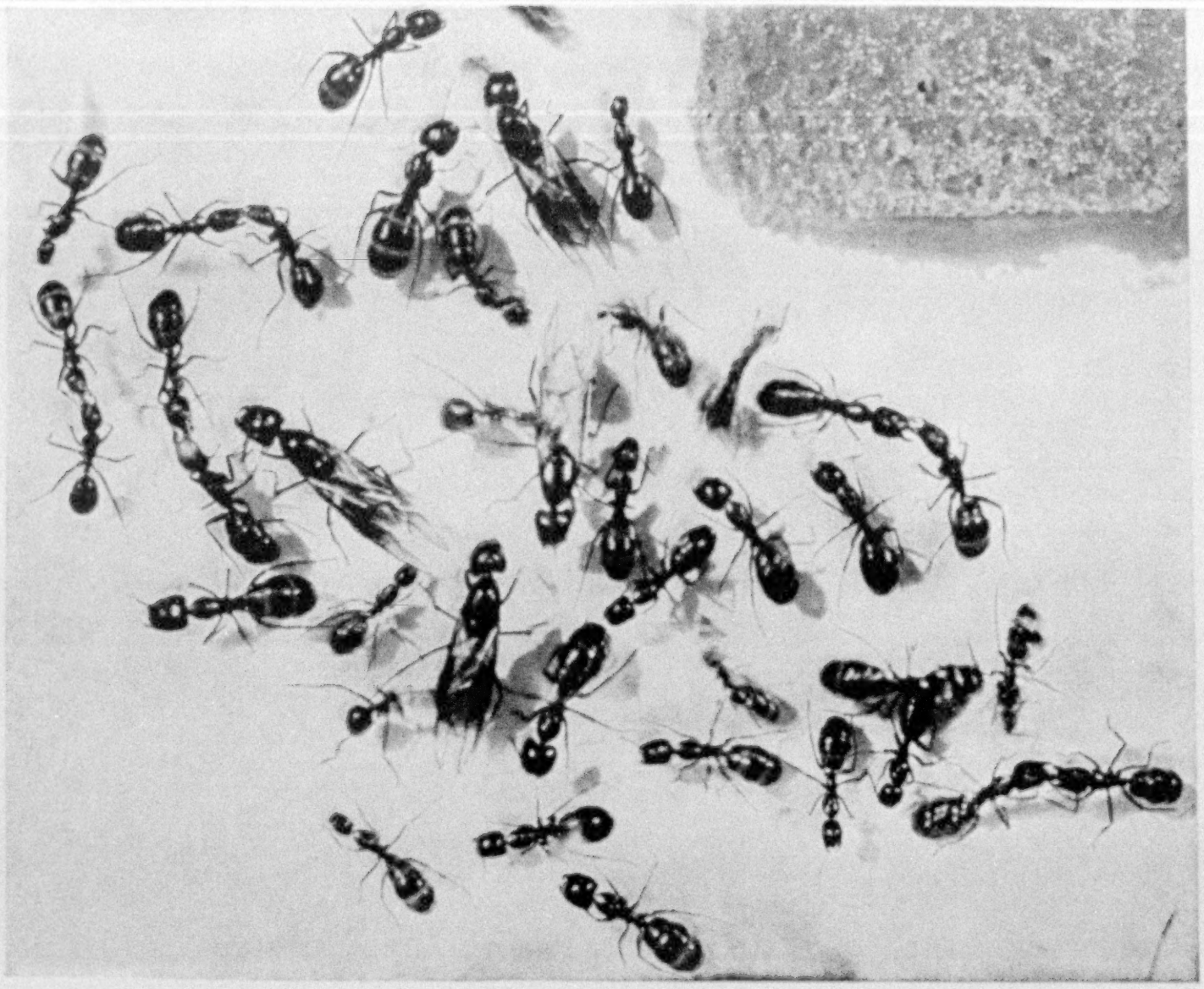
QUEENS OF A COMMON ANT (*Camponotus americanus*)

One of the queens is fecundated and has lost her wings and is thus prepared to start a colony. Ant societies are societies of females. The males really take no part in the colonial activities, and, in most species, are present in the nest only for the brief period requisite to insure the impregnation of the young queens. The males take no part in building, provisioning, or guarding the nest, or in feeding the workers or the brood. They are in every sense the *sexus sequior*. Hence the ants resemble certain mythical human societies like the Amazons, but, unlike these, all their activities center in the multiplication and care of the coming generations.

whenever they signify their hunger by protruding their tongues and making supplicatory gestures with their feelers, and because none of the food in this receptacle can be used by the individual unless it passes back through the valve into the true stomach.

The crop is thus a storage reservoir from which both the individual and the colony can be supplied with nutriment. Other older and cruder methods of the distribution and storage of food coexist among ants with this more modern and more efficient method.

Thus solid foods may be carried into the nest entire and then dismembered and the pieces distributed to different parts of the nest to be still further comminuted and sucked dry by groups of ants, or the solid food may be carefully stored in special chambers.



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PORTION OF A *Camponotus americanus* COLONY WITH WORKERS AND VIRGIN QUEENS

Five pairs of workers are seen in the act of feeding one another by regurgitating liquid food from the social stomach or crop. Many observers, especially McCook, have dwelt on the exquisite care bestowed by ants on their own bodies and those of their comrades. Much of the time spent by these insects in the dark recesses of their nests is devoted to cleansing the surfaces of their bodies with their tongues and strigils. This process is not only necessary for removing all particles of the earth in which the ants work so much of their lives, but it also invests their bodies with a coating of slightly oleaginous saliva, which probably protects them from moisture and may be sufficiently antiseptic to prevent the growth of lethal moulds and bacteria.

A DETERMINED ATTEMPT AT SELF CIVILIZATION

As ants were primitively carnivorous or predacious insects, it is rather difficult to understand how they could have developed societies at all, for as a general rule we find that predacious animals, which have to hunt their prey or to lie in wait for it, like the spiders, hawks, and tigers, live solitary lives, and that only vegetarians like the caterpillars, sparrows, rodents, and ruminants, which have easy access to a large amount of food, develop gregarious or social habits.

There can be no doubt that the ants have found it difficult to reconcile their carnivorous appetites with their social proclivities, for we find that they have attempted this reconciliation in diverse ways.

Most of the species of the oldest, most primitive, and most conservative subfamily, the Ponerinæ, have not been able to relinquish their carnivorous habits, and have therefore been prevented from forming large colonies. Most of the species of this subfamily, in fact, form colonies of only a few dozen individuals, and these colonies are, moreover, rare and depauperate in appearance.

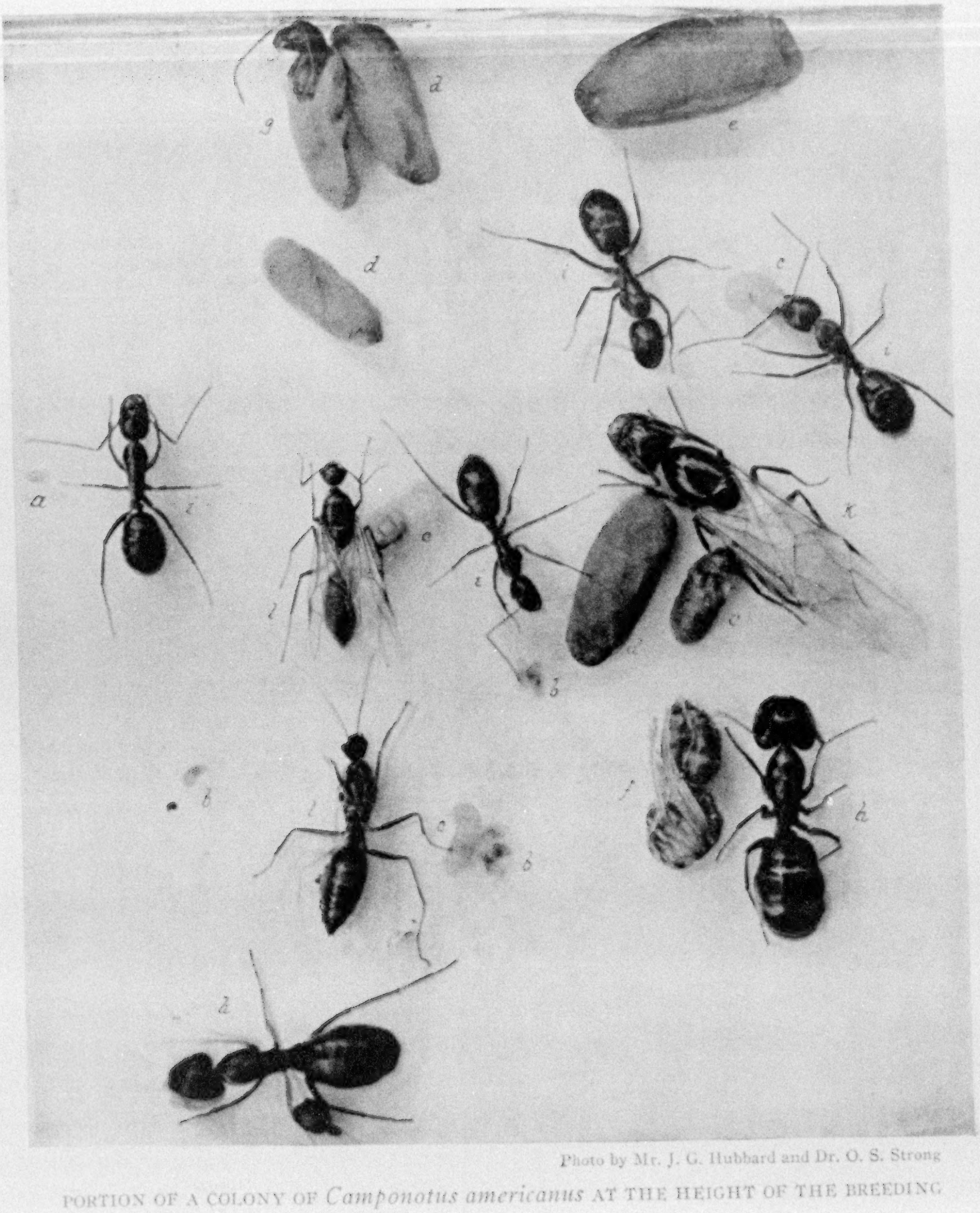

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

PORTION OF A COLONY OF *Camponotus americanus* AT THE HEIGHT OF THE BREEDING SEASON

a, egg; *b*, young larvæ; *c*, older larvæ; *d*, worker cocoons; *e*, queen cocoon; *f*, worker major pupa removed from cocoon; *g*, worker media, in the act of hatching; *h*, major workers; *i*, minor workers; *k*, virgin female, or queen; *l*, males. Magnification about two diameters.

Another subfamily, the Dorylinæ, embracing the wonderful driver ants of Africa and the legionary ants of the American tropics, are also highly carnivorous, but nevertheless succeed in forming immense colonies, often of hundreds of thousands of individuals. This they accomplish by relinquishing the sedentary habits so characteristic of the great majority of ants. They keep moving in long files through the jungles, capturing or killing all the insects they encounter, and even overrunning dwellings, and, in their search for cockroaches and other vermin, driving out the human inhabitants. From time to time these strange ants bivouac for the night or for a few days in some hole in the ground, or under a tree, but soon continue their predatory march. Evidently they are able to remain carnivorous, and at the same time to develop large colonies, only because they are nomadic and can thus draw their food supply from a large area.

The Ponerinæ and Dorylinæ ants have thus adopted the only modes of life which will permit a union of predatism and sociability.

Their colonies must either remain small and rare, or, if populous, must keep moving from place to place. As each of these conditions has serious disadvantages, we find that the majority of ants have preferred to become more and more vegetarian, though, like man, usually without completely abandoning their carnivorous appetites.

A FAVORITE FOOD

One of the earliest departures from an exclusively animal diet is seen among the ants which attend plant-lice, scale insects, and leaf-hoppers and feed on their saccharine excrement. This excrement is, of course, merely plant sap slightly altered in its chemical constitution by passing through the digestive tract of the insects, and containing much water, some sugar, and a little nitrogenous matter.

Many ants are so inordinately fond of this food that they not only acquire an intimate acquaintance with the habits of the adult plant-lice and scale insects, but actually collect and store their eggs in the nests during winter in order that they may during the ensuing spring distribute the hatching young over the roots or foliage of the plants. This is a well-developed habit among the species of *Lasius* throughout temperate North America and Eurasia (see pictures, pages 743, 744).

Other plant juices, such as the nectar of flowers and the similar liquid secreted by the glands on the petioles of leaves and by green galls, are also assiduously collected by ants. There is, moreover, a singular tendency for some ants which are engaged in this collection of nectar and plant-lice excrement to become "honey-ants" through an extraordinary exaggeration of the instinct to store liquid food in the crop or social stomach.

LIVING STOREHOUSES FOR FOOD

Certain individuals, the "repletes," of the colony refrain from leaving the nest and foraging for food and become converted into flagons by distending the crop to such enormous dimensions that the abdomen looks like a transparent bead (see pictures, pages 747, 748). In this condition they hang by their claws from the roof of the nest chamber and thenceforth spend all their lives receiving liquid food from the tongues of the foraging ants, storing it in their crops, and regurgitating it to hungry individuals when the liquid food supply outside the nest becomes inadequate. This is, of course, apt to be the case periodically in dry regions, so that we find the true honey-ants only in deserts like those of the southwestern states, northern Mexico, South Africa, and central Australia.

In such localities also a further adaptation to vegetarianism may be frequently observed in many species of ants which take to harvesting and eating the seeds of the small herbaceous plants. This harvesting habit is evidently a last resort in regions where insect food is very scarce or confined to a brief season.

There are several dozen species of harvesting ants in North America alone, the most conspicuous being those of the genus *Pogonomyrmex*, the species of which range all the way from Montana to the Argentine through the dry western portions of two continents. It was for-

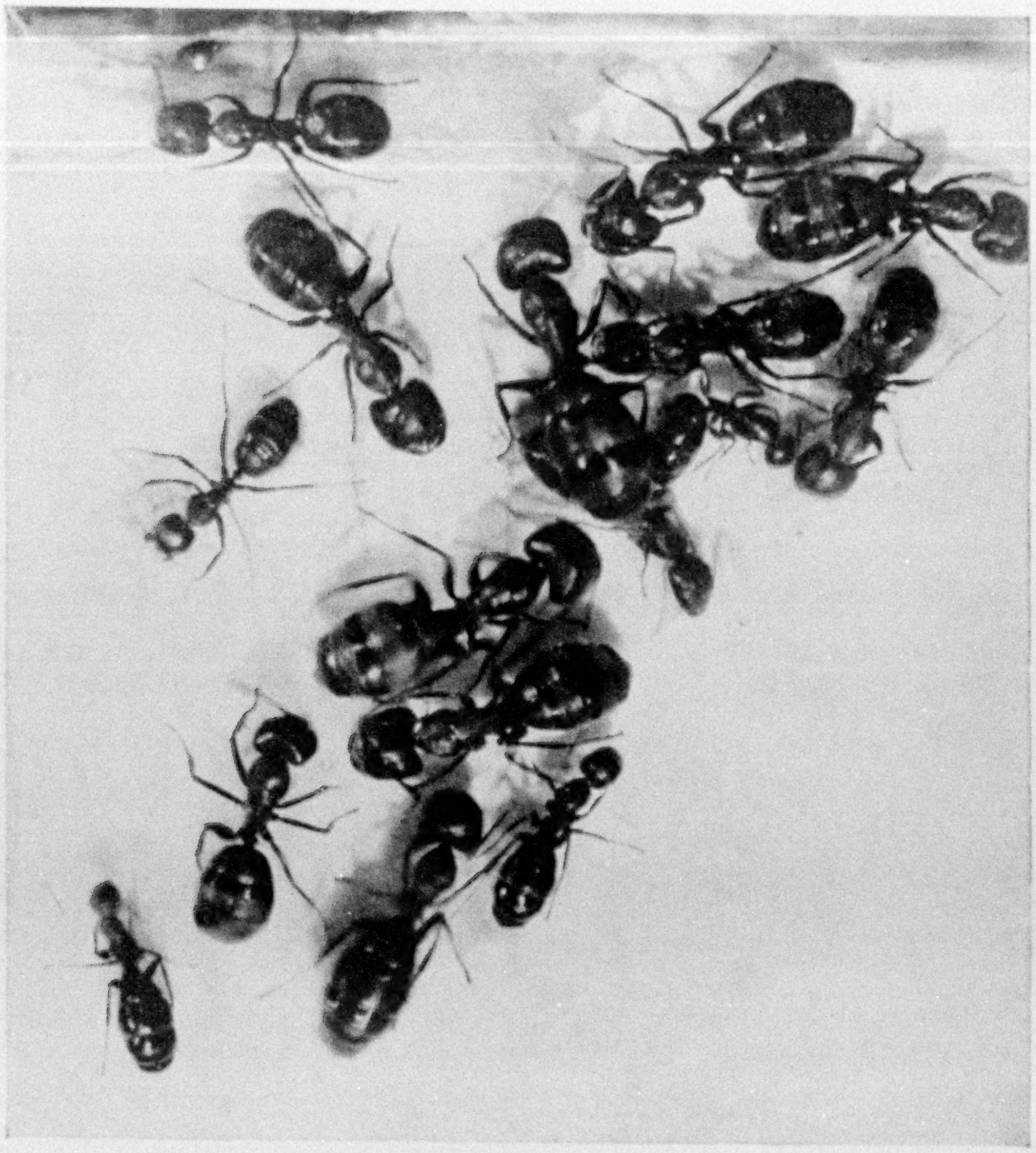

Photo by the Author

MAJOR AND MINOR WORKERS OF *Camponotus americanus*

The worker is produced by inadequate nourishment; is "a hunger form." Magnification about two diameters (see text, page 742)

merly supposed that these ants intentionally sowed seeds in the ground in order that they might later harvest the crop, but this supposition has been shown to be erroneous. The ants merely visit the plants, which are often at some distance from the nest, and carry the seeds home over well-beaten paths.

FARMER ANTS

That ants can carry on agricultural or horticultural pursuits has, however, been proved by a study of the peculiar Attii, a tribe comprising more than a hundred species, all confined to America and nearly all to the tropics. These ants live on fungi which they cultivate on beds of triturated leaves, or insect excrement in specially excavated chambers.

The large species of the genus *Atta* cut pieces of leaves from trees, carry them into the nest in great numbers, cut them into smaller fragments, and build them up on the floors of the chambers into sponge-like masses, over the surface of which a delicate white fungus rapidly proliferates. This fungus, which is constantly weeded by the smallest ants in the colony, is prevented from fruiting and constrained to produce peculiar clus-

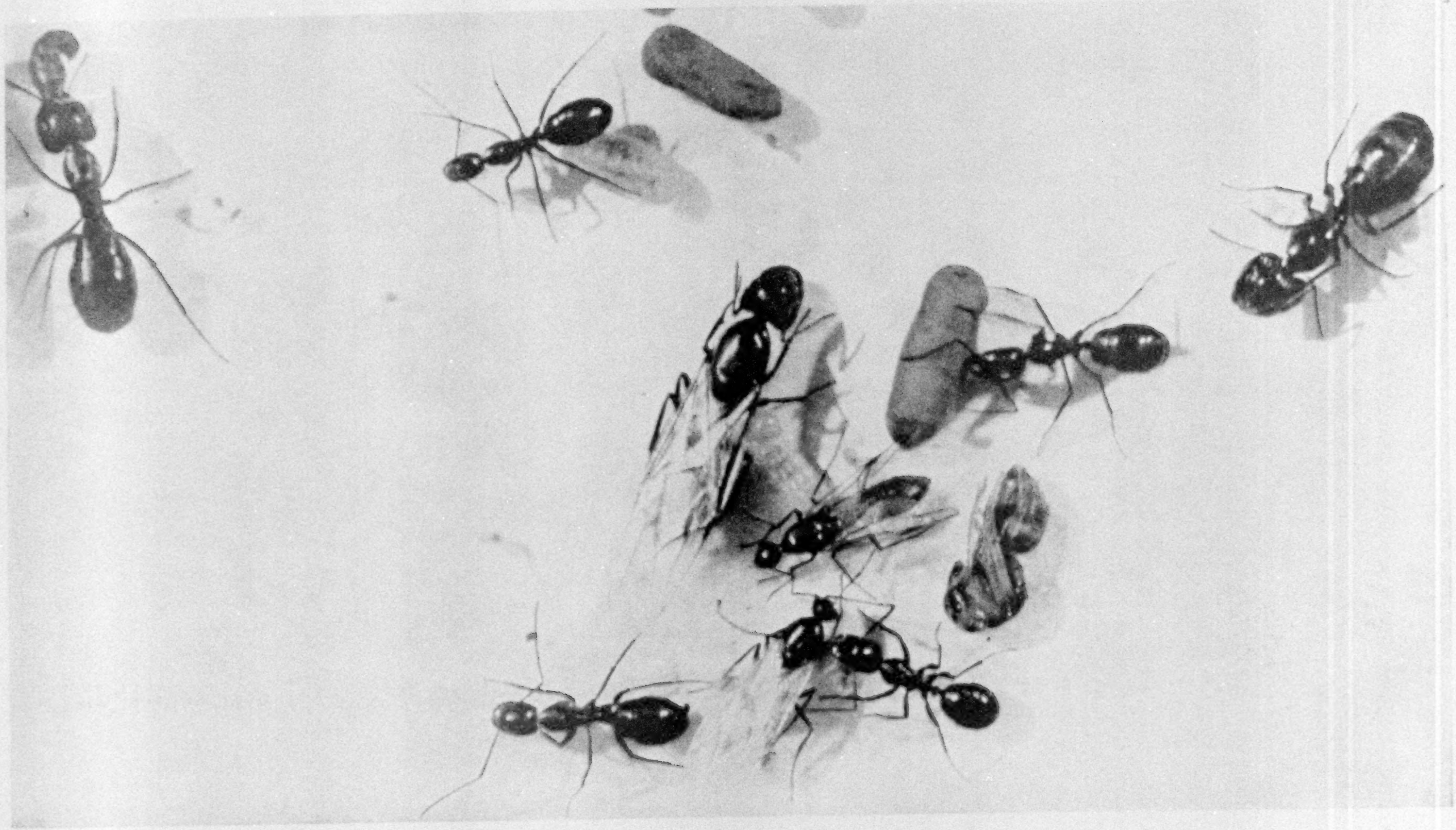

Photo by Mr. J. C. Hubbard and Dr. O. S. Strong

PORTION OF COLONY OF *Camponotus americanus*

The large, winged individual is a virgin queen; the two smaller ones are males; the large-headed wingless individuals are major, the small-headed ones minor workers. A major worker, in the left-hand upper corner, is carrying a half-grown larva in its mandibles. Eggs, very young larvæ, cocoons, and one pupa removed from its cocoon are also shown. Magnification about two diameters.

XUM

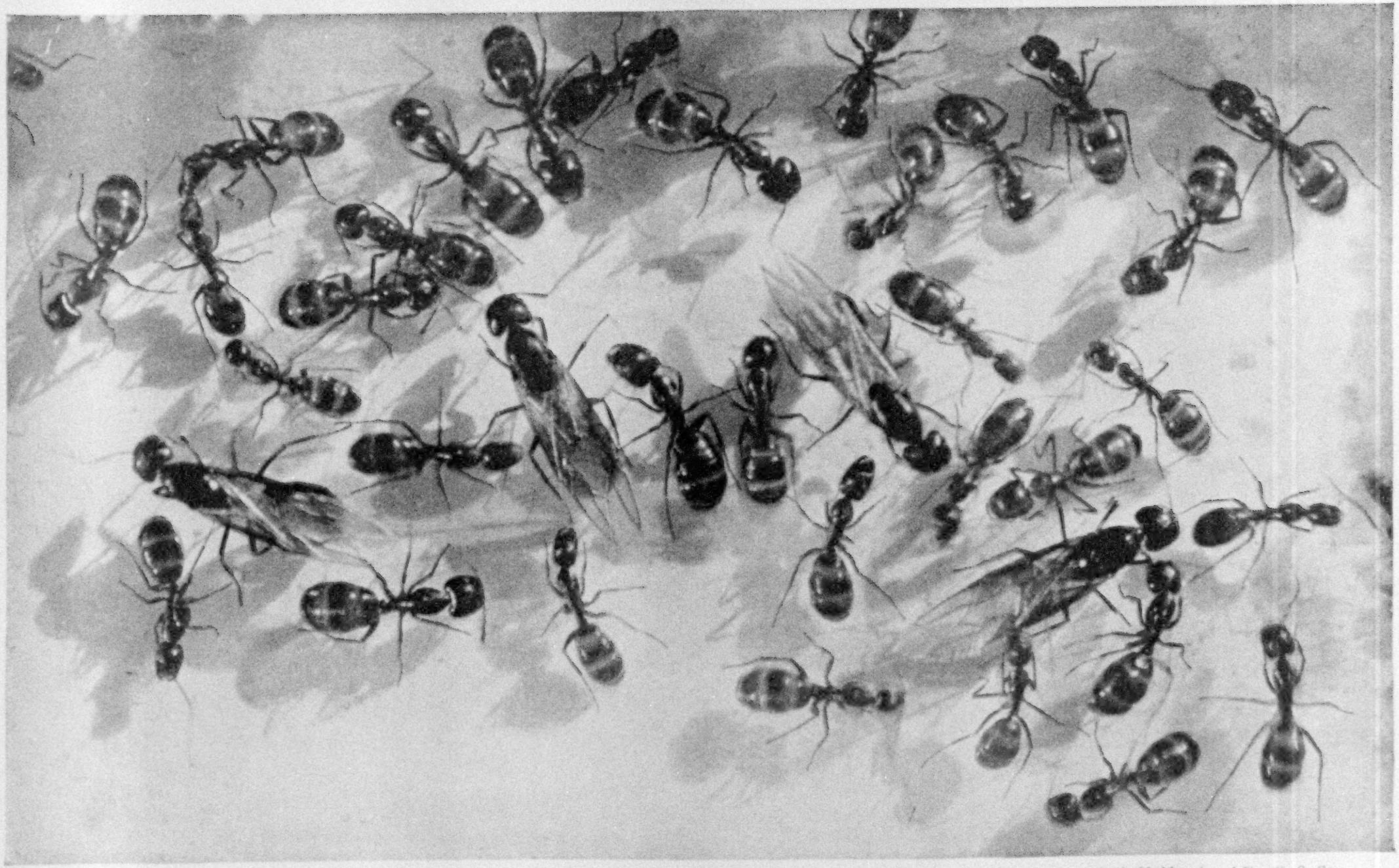

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

PORTION OF COLONY OF *Camponotus americanus*

Four virgin queens and numerous workers. In the upper left-hand corner one of the workers is seen in the act of receiving food from another by regurgitation. Magnification about two diameters

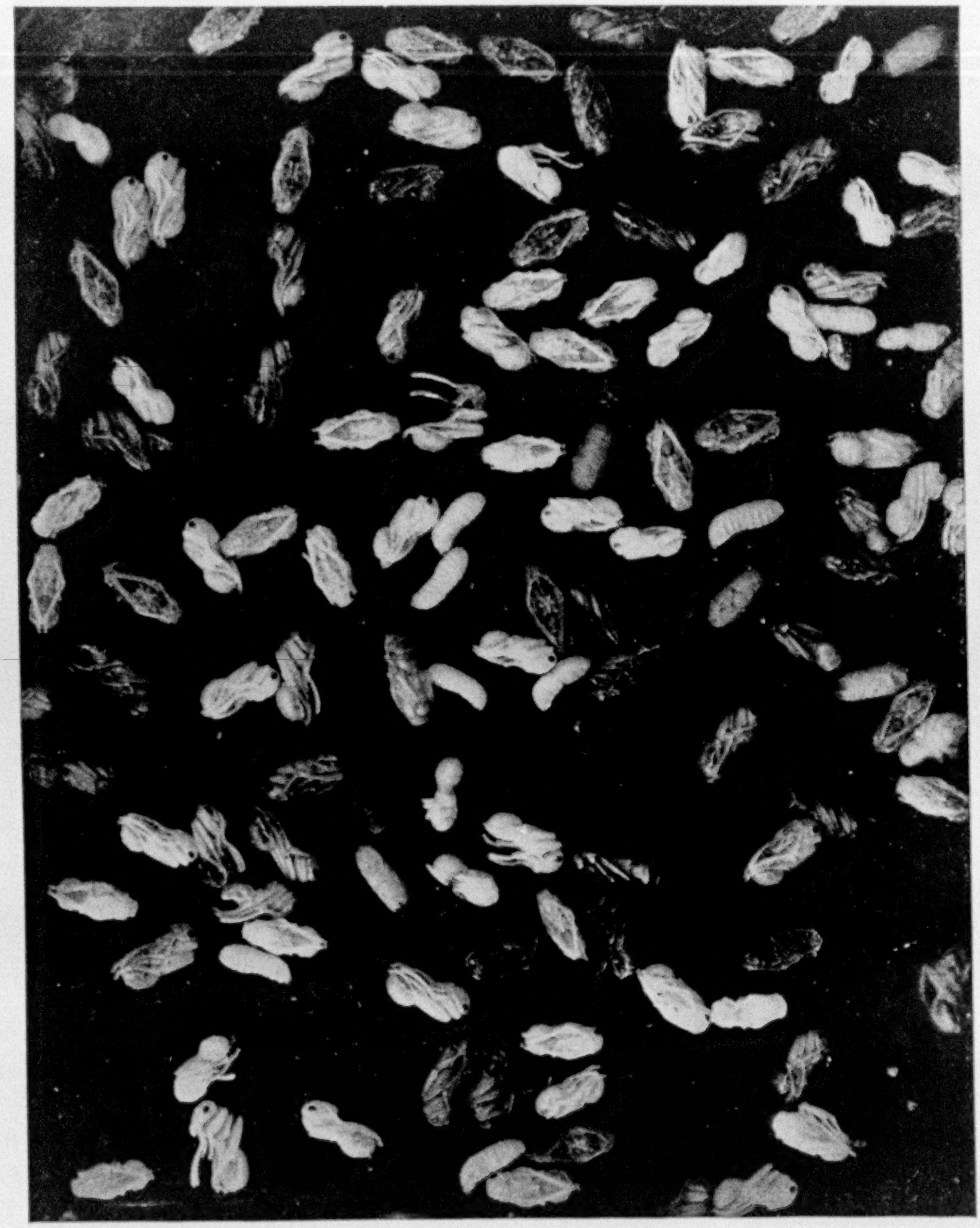

Photo by the Author

ADULT WORKER LARVÆ, SEMI-PUPÆ, AND NUDE AND COVERED PUPÆ IN VARIOUS STAGES OF PIGMENTATION OF *Formica subsericea*

Magnification two diameters

ters of small, glistening food-bodies called "ambrosia" (see pictures, pages 750-754).

Some of the small Attii, instead of building their fungus-gardens on the floors, suspend them from the ceiling of the chambers, so that the masses of substratum clothed with fungus filaments hang down like white velvet curtains. This habit is beautifully developed in several species of *Trachymyrmex* and *Mycetosoritis*. One of these, *Trachymyrmex septentrionalis*, ranges as far north as the pine-barrens of New Jersey.

None of the Attii or their larvæ, so far as known, can eat anything except the particular kind of fungus which they cultivate. To appreciate the advantages to which these completely vegetarian ants have attained in thus substituting an easily controllable and abundant food-supply for the scarce and precarious insect diet of their predatory ancestors, one must observe these wonderful ants in Brazil or Central America, moving over their long trails in interminable processions, defoliating whole trees and carrying their leafy burdens like banners to their huge nest craters, which often spread over a quarter of an acre or more.

The foregoing remarks show that the ethnic history of ants parallels that of man to the extent that these insects were originally flesh-eating hunters, then shepherds of food-producing herds, and finally agriculturists, and that they have been compelled to pass through these stages or forfeit the advantages of living in populous and stationary communities. It is evident, furthermore, that the social needs of ants, like those of man, have been even more exigent than hunger.

SOCIAL DIETITIANS

The skill and success with which the higher ants have thus adapted their diet to the requirements of sociability contrasts markedly with the conditions in the other social insects. The social wasps are carnivorous, to be sure, but their colonies are small and rare like those of the Ponerinæ, and in temperate regions merely annual growths. The social bees have retained the exclusively vegetarian diet of their solitary ancestors, but, as they have greatly specialized by restricting this diet to nectar and pollen, they have become dangerously dependent on the evanescent flowers. And though they have learned to construct a wonderful system of cells for food storage, they are quite unable to control the food supply. Finally, the termites, though completely vegetarian, have also become too specialized by restricting their diet to wood, or cellulose, a hard and innutritious substance, which, though abundant, can be assimilated only with great difficulty.

It is significant, therefore, that the termites of Africa and the Indomalayan region, which form the largest and most aggressive colonies, have become fungus-growers. But even these have not yet learned, like the Attiine ants, to grow "ambrosia" for all the members of the colony. The working population of the nests still has to live on wood in order to produce the excrement which is used in the construction of the gardens. The fungus itself is fed only to the young and to the sexual individuals.

It is a biological axiom that all organisms tend to propagate so rapidly that they are continually in danger of outrunning their food supply. This danger is even greater in the social or colonial than in the solitary organism, because the former is necessarily much hampered in its movements, and if every individual of which the colony consists be permitted to reproduce the food supply would very soon become so inadequate as seriously to impair the functions of the community as a whole. Hence it is not surprising that all social or colonial organisms are bound to restrict the reproductive function of their component individuals. This is true even of the individual organism itself regarded as a colony of cells.

REGULATING THE GROWTH OF FAMILIES

The four groups of social insects have, therefore, had to face a very difficult problem, and it is interesting to note that they have solved it in essentially the same manner as other social aggregates, the cell-aggregate, or individual organism included, namely, by restricting the reproductive function to a very few of the component individuals and by reducing

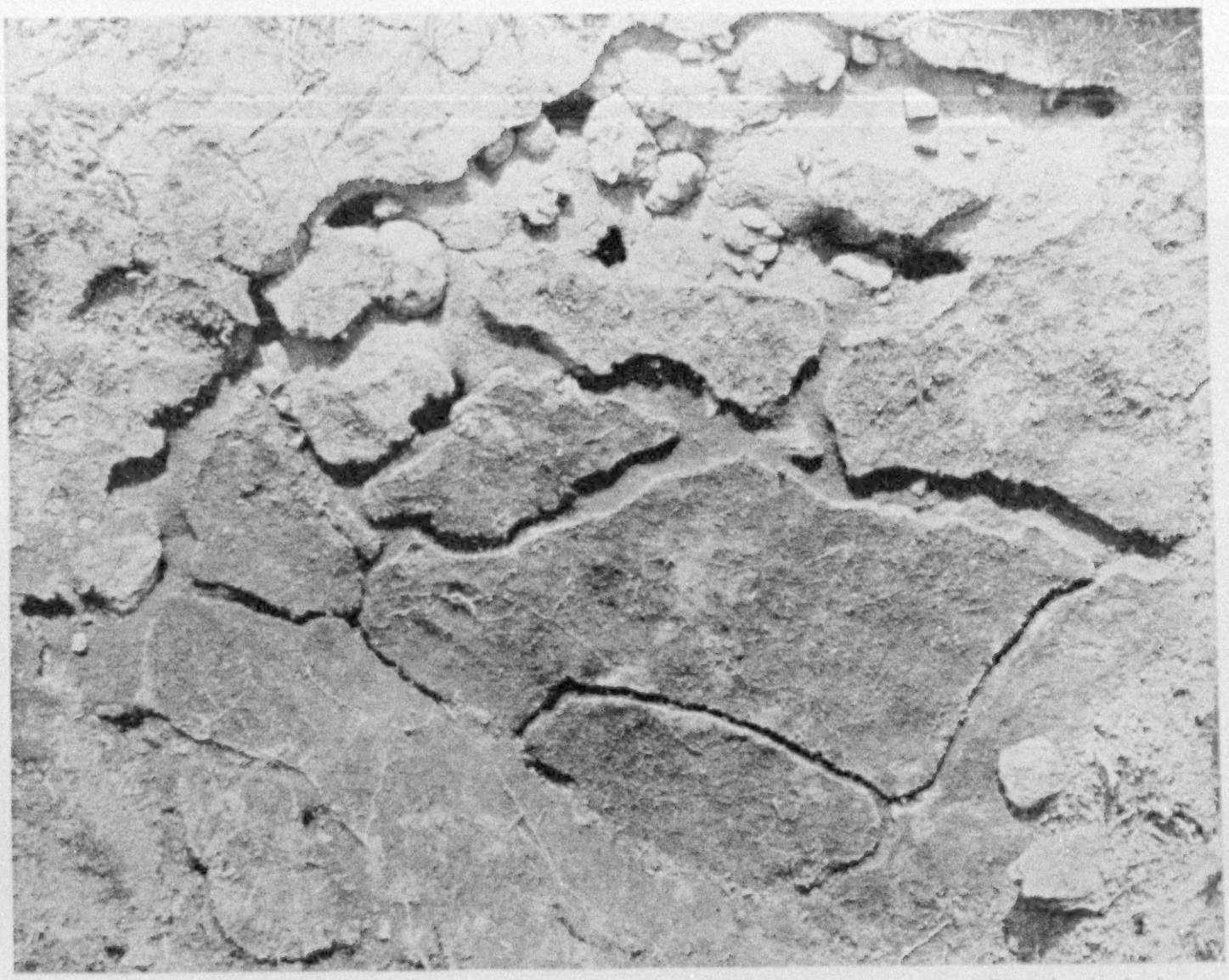

Photo by the Author

NEST OF A VERY COMMON ANT: *Lasius (Acanthomyops) latipes*

Only the irregular superficial galleries and chambers are shown as they appear when the stone covering the nest is removed. The care of the nest is an important matter with all ants, for convenience, no less than sanitation, requires that the galleries and chambers be kept scrupulously clean. All species, therefore, remove any refuse food, empty cocoons, pupal exuviæ, meconial pellets, dead members of the colony, etc., to a proper distance from the living apartments. Veritable kitchen middens are established for this purpose, either in the open air or, if the colony is nesting under a large stone, in one of the deserted surface galleries.

the great majority to sterility and endowing them with a purely nutritive or protective function.

Nevertheless there are some interesting minor differences in the solutions of the problem of reproduction as exhibited by the termites on the one hand and the social Hymenoptera on the other. Although both of these groups bring up their brood in such a manner that the majority of individuals in the colony are sterile and only a few normally capable of reproduction, the termites make sterile or worker forms out of both male and female individuals, whereas the wasps, bees, and ants produce sterile forms only among the females and merely reduce the number of males and permit them to develop only at certain seasons.

Hence among the social Hymenoptera we have three castes: males, fertile females, or queens and sterile females, or workers. The workers among ants and termites, however, may be still further differentiated into workers proper and soldiers, the former having a nutritive, the latter a protective, function.

This remarkable method of reducing the reproductivity of a society, whilst insuring its nutritive success, is of no little interest at the present time. It is probably not a mere coincidence that we

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

WORKERS AND COCOONS OF THE ANT WHICH PASTURES AND GUARDS PLANT-LICE: *Lasius* (*Acanthomyops*) *claviger* (SEE TEXT, PAGES 735, 736)

This is a common herder of root-lice in the northern States. From the small cocoons males and workers will hatch; from the two large ones queens. The pale individuals at *a* are just-hatched callows. Magnification about two diameters.

should be most diligently discussing eugenics, or the restriction of reproduction to the sane in mind and body, at a time when we are also most exercised by the high cost of living. Did space permit, it could be shown that man, like other social organisms, has for ages sought and is still seeking means of regulating the reproductivity of his race to prevent its exceeding its food supply, and that the expedients on which he has relied in the past, such as monasticism, wars, and the adoption of religious, property, and caste restrictions to marriage, have been only partially successful.

In termites, both sexes, as we have seen, coöperate equally in the activities of the colony, so that each nest contains, besides a king and queen, a host of workers and soldiers of both sexes. The colonies of ants and the other social Hymenoptera, however, are essentially feminine, since they contain one or more queens and a great number of workers, which are all sterile females, and only at certain times of the year contain any males. These, moreover, take no part in the colonial activities, but live only to mate with the queens of other colonies during the annual marriage flight.

We are therefore prepared to find that maternity is the pivotal instinct about which all the activities of the ant colony revolve. Not only the queen, the repro-

A COLONY OF THE ANT WHICH HOARDS THE EGGS OF THE CORN-ROOT LOUSE IN ITS NESTS OVER WINTER AND DISTRIBUTES THE JUST-HATCHED YOUNG IN THE SPRING ALONG THE ROOTS OF THE MAIZE

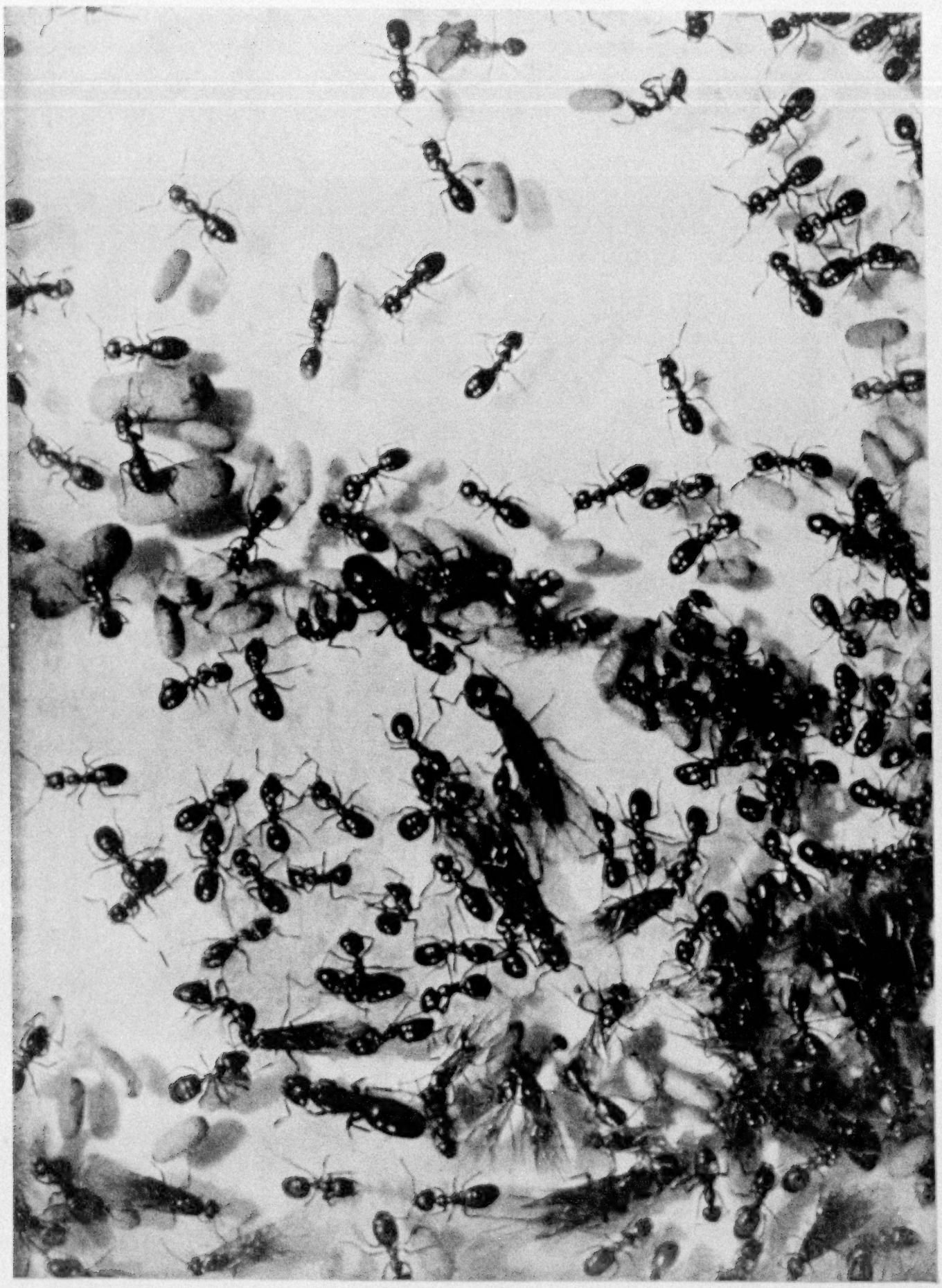

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

COLONY OF *Lasius (Acanthomyops) claviger,* A COMMON SUBTERRANEAN ANT IN THE WOODS OF THE EASTERN STATES, WHICH NURSES THE ROOT LICE

Two mother queens, without wings, several winged or virgin queens, and males are scattered through the throng of workers. Three queen cocoons and numerous worker cocoons are also shown. Magnification about two diameters (see pages 735, 736).

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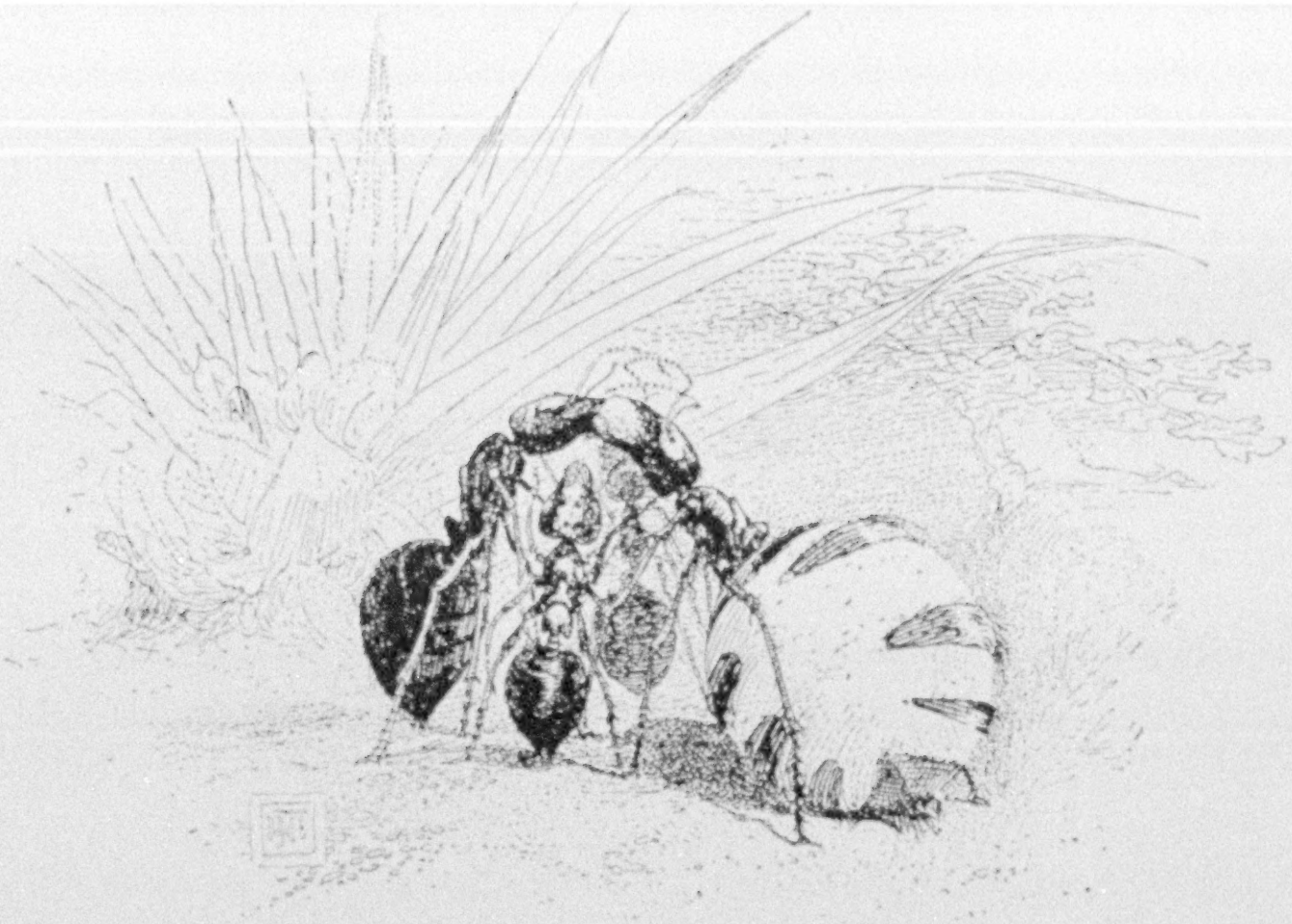


THE HONEY ANT, WHOSE STOMACH IS DEVELOPED INTO A FOOD RESERVOIR FOR THE REST OF THE ANT COLONY

The picture shows the honey ant (*Myrmecocystus hortideorum*) in the act of regurgitating food to workers of the ordinary form. (After H. McCook.) (See text, page 736.)

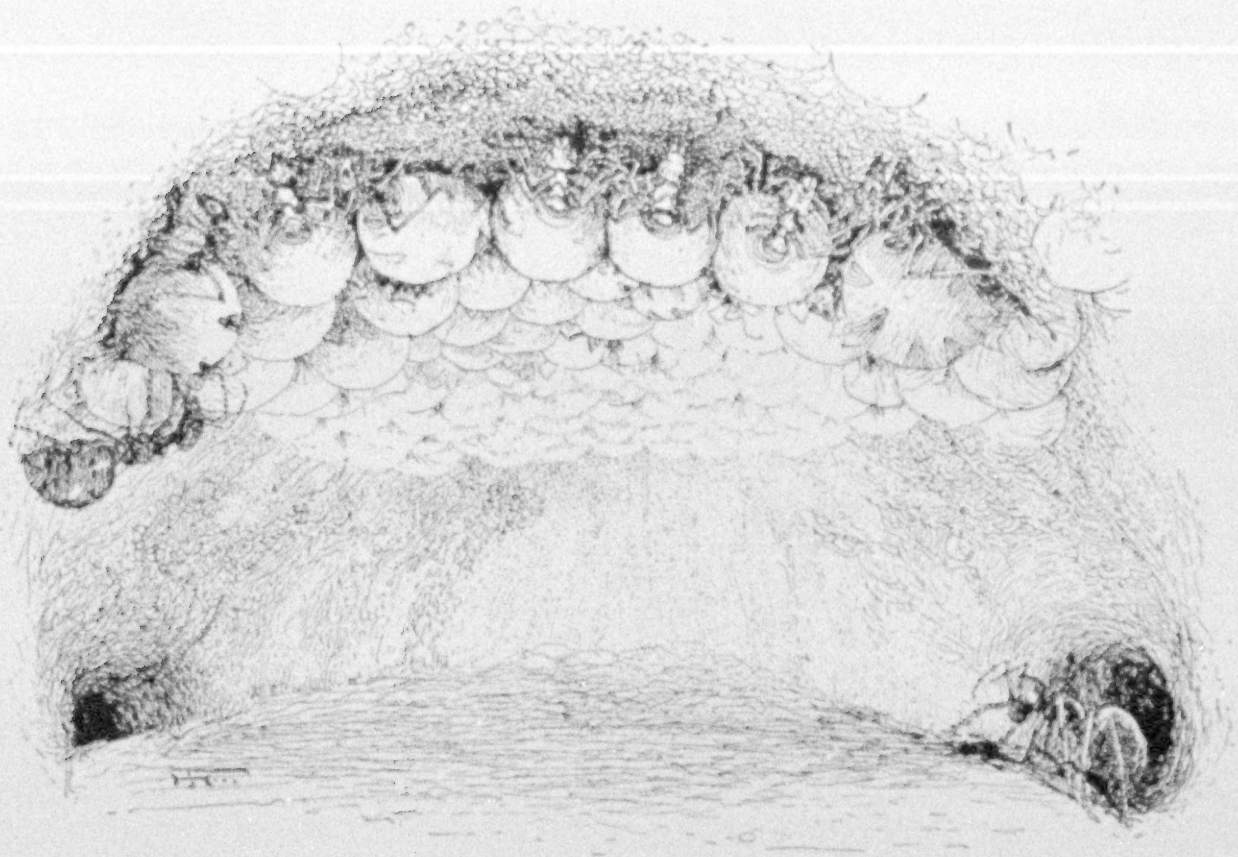
ductive center of the colony, but all the workers act as though they were obsessed with a perfect mania of reproduction and nursing. Unless this fact is clearly appreciated, much of the behavior of ants will remain enigmatic, meaningless, or absurd.

Nothing shows more clearly the strength of the maternal instincts in ants than the development of the colony from its inception till it becomes in turn the mother of other colonies. After mating with the male high in the air, the queen descends to earth and loses her wings, either by breaking them off at the base against the stones or blades of grass or by tearing them away with her mandibles, for they are to be of no further use to her. She then seeks some small cavity under a stone or piece of bark, or digs one in the ground, and closes it after her, so that she is completely shut off from the world (see picture, page 763).

In this little cell she passes days, weeks, or even months without food while waiting for the eggs in her ovaries to mature. The now useless wing-muscles, which fill her large thorax, dissolve in the blood and go to build up the yolk of the eggs, and a similar fate overtakes the great masses of fat which she stored away in her abdomen during her larval life in the maternal nest.

THE INFANT OFFSPRING FEED THE STARVING MOTHER

Eventually she lays a small batch of eggs and cares for them till they hatch as helpless grub-like larvæ. These she feeds with her saliva, but as the supply of this is meager, the larvæ grow slowly, pupate prematurely, and emerge as very small and feeble workers. They nevertheless at once set to work to expand the colony by opening up a gallery to the outside world and go forth to forage. They bring in food to their starving mother and henceforth spend their days in foraging, enlarging the nest by excavating additional galleries and chambers, and in



The "replete" workers, with their social stomachs distended with the sweet exudations of oak galls, hang from the vaulted roof of the chamber in a cluster and function as so many food reservoirs. (After H. McCook.) (See text, page 736).

rearing the successive broods of larvæ from the eggs which the queen is now able to produce in quantities.

The larvæ are fed more abundantly as the number of workers increases, and therefore develop into larger and more vigorous individuals. As time goes on and at the proper season, male larvæ appear and develop, and the female larvæ are so well fed that they can develop beyond the worker stage and become queens.

With the appearance of these sexual forms the colony has reached maturity, and although it may persist for many years, it merely repeats each year this same cycle of feeding and rearing as great a number of individuals as possible on the amount of food which the workers can secure.

The queen may live a dozen years or more, and each worker may live three to four years, but the males usually live only a few weeks and die after the nuptial flight, being exhausted and knowing neither how to feed themselves nor how to return to the nest.

THE HIGHEST DEGREE OF SELF-SACRIFICE

Most extraordinary during the development of the ant colony is the behavior of the workers, for though sterile and, under ordinary circumstances, unable to lay eggs, they nevertheless exhibit all the other maternal instincts in an exaggerated degree. The worker, as we have seen, is a form produced by inadequate nourishment. It is a hunger form, so inured to long fasting during its larval life that even when it reaches maturity it seems to prefer to starve, for though greedy to fill its social stomach with liquid food whenever there is an opportunity, it dispenses this store most generously to the larvæ and its sister ants and permits very little of it to pass the valve into the individual stomach, only enough, in fact, to maintain healthful activity.

Ants are, therefore, the most thoroughgoing of communists, to whom individual possession as such has no meaning beyond its benefit to the community as a whole.

But even the worker's sterility, which has given certain individualistic thinkers such bad dreams, is neither fixed nor irrevocable. If the colony has a very abundant food supply, or if its queen dies, the small, undeveloped eggs, which are always present in the ovaries of the workers, may grow to full size, be de-

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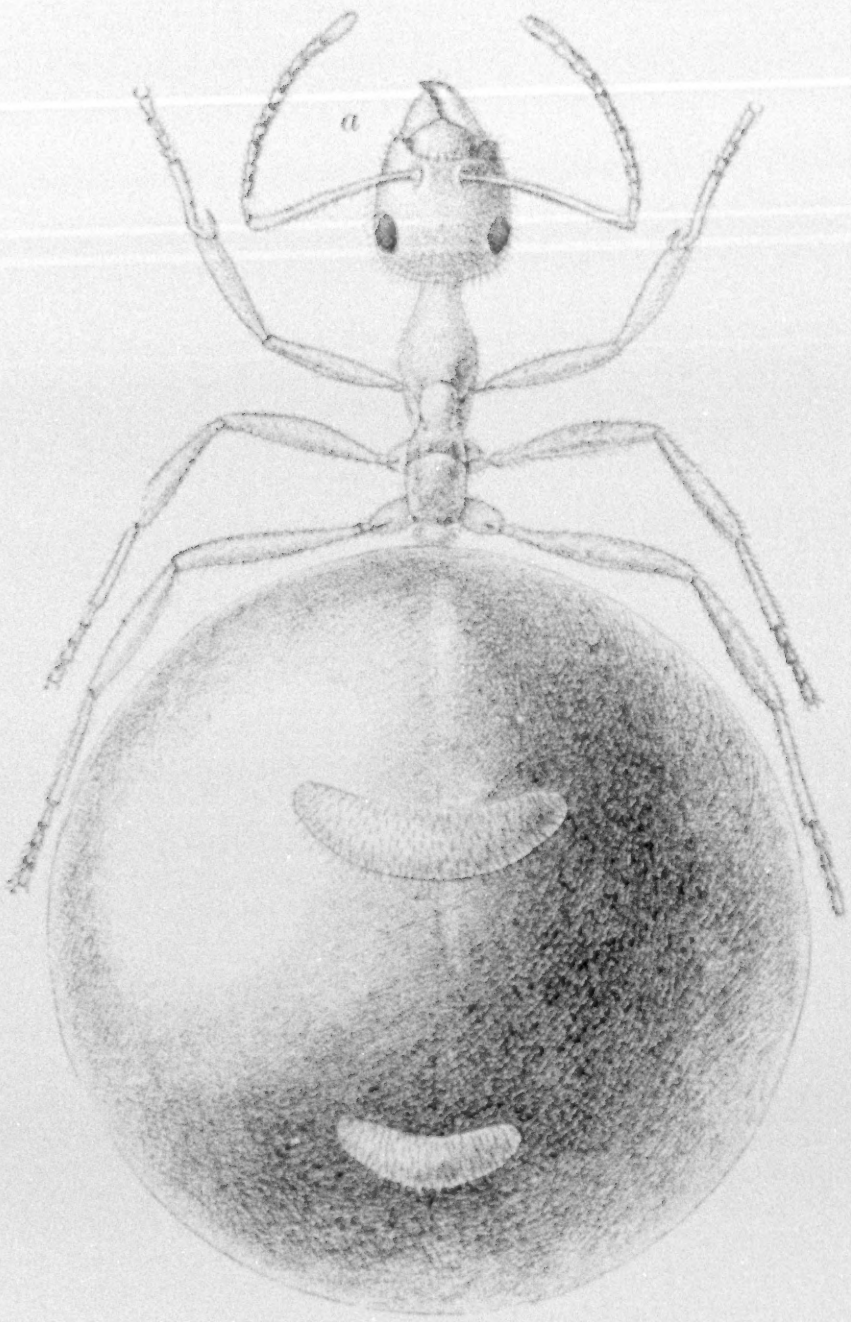
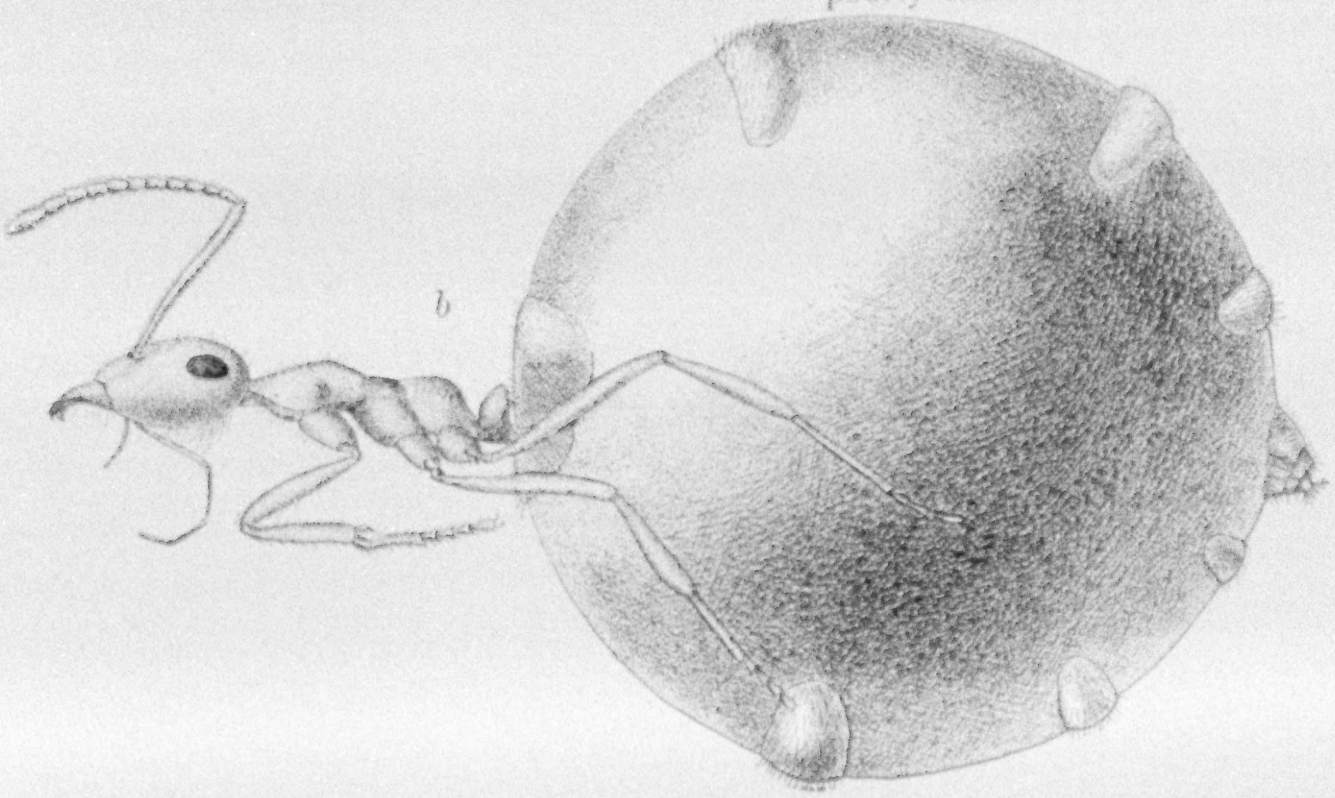


posited and develop normally, though always or nearly always into male ants, because they are not fertilized. Thus the joys of maternity may fall to the lot of the worker, though less abundantly and less frequently than to that of the queen.

The founding of the colony as described in the foregoing paragraphs is typical of the great majority of ants, but there are several other methods, which may be briefly considered, since they still further accentuate the remarkable fondness of these insects for their brood. These methods are determined by the different endowment with which the queen ants of different species leave the maternal nest.

In most species, as already described, the recently fecundated queen possesses a large fat body and a mass of wing muscles, which can be converted into food for the eggs and a complicated instinct endowment, which enables her to found a nest and bring up a first brood of young without the aid of workers. There are queens, however, even better and some that are much more poorly endowed.



THE FAMILY STOMACH OR REPLETES OF THE HONEY ANT OF THE GARDEN OF THE GODS (*Myrmecocystus hortideorum*)

a shows the insects as seen from above; *b* in profile. In both the segments of the abdomen are widely separated by the thin intersegmental membrane, which is greatly stretched by the distended crop, or social stomach. (Author's illustration.) (See text, page 736.)

BORN WITH A WELL-STOCKED LARDER

To the former class belongs the queen of the fungus-growing ants, which not only leaves the maternal nest with the mental and bodily endowment of the ordinary queen, but also inherits some property in the form of a bundle of fungus filaments from the gardens of the maternal nest, tucked away in the little pocket in the floor of her mouth. After she has excavated her chamber in the soil and closed its entrance, she is thus in a position not only to bring up a first brood without extraneous aid, but to start the gardens with the fungus pellet, which she spits out, and keeps growing by careful weeding and by manuring it from time to time with her excrement, or even with her own broken eggs, till the firstling workers hatch and begin to bring in the leaf material or caterpillar excrement, which is henceforth used as the only substratum for the gardens.

Very different is the endowment of the queens of a number of parasitic ants. These queens are either very small and feeble or lack the instincts and initiative that would enable them to found a colony independently. They are therefore compelled to seek assistance in this arduous task, and they succeed in securing it in one of the three following ways:

The young queens of some parasitic ants enter the colonies of an allied species, the workers of which then either kill their own queen and adopt the parasite in her stead or permit the latter to kill their queen. After the reproductive center of the host colony has been thus destroyed, the intrusive queen lays her eggs and permits her young to be brought up by the alien workers. These die off in the course of a few years, but by that time they have reared at least one brood of the parasitic species and the colony, now consisting exclusively of the queen and workers of this species, is sufficiently vigorous to lead an independent existence. This method of colony formation, in which the queen is relieved from the difficult task of feeding and rearing a first brood, has been called temporary social parasitism. It is characteristic of many of the largest and most prosperous ants of the north temperate zone—*e. g.*, of the mound-building ant of the Alleghanies (*Formica exsectoides*) and the fallow ant of Europe (*F. rufa*).

THE KIDNAPPERS

A different method is adopted by the slave-making ant *Formica sanguinea* and many of its subspecies (see picture, page 755). The young queen enters a nest of the common black *Formica fusca* or of some one of its many varieties, kills or drives away any of the workers when, irritated by her odor, they rush forth to attack her, then hastily collects a lot of the worker pupæ of the *fusca* and stands guard over and defends them till they hatch. These workers at once affiliate themselves with the queen as intimately as if she were their own mother and bring up her brood for her as soon as it appears.

The *sanguinea* young inherit their mother's peculiar instinct to attack the *fusca* colonies in the neighborhood and to kidnap the worker pupæ. They bring these pupæ back to the maternal nest and eat some of them, but permit others to hatch and become "auxiliaries," or "slaves." Thus what has been called slavery among ants is merely a form of parasitism, in which the "slave" species is really the host. In old colonies the *sanguinea* workers often lose the slave-making habit, and as the *fusca* workers then completely die out, there ensues an emancipation of the *sanguinea* colony from the host like that observed in the temporary social parasites.

THE SLAVERS

A third method is adopted by the young queens of the permanent social parasites. These queens enter the colonies of an alien species and are adopted like the queens of the temporary social parasites, after the enforced death of the host queen, but the worker offspring of the parasite are destined always to live with the host species. There are really two methods of insuring this result. One is by slavery, as in the case of the amazon ants (*Polyergus*), the workers of which are unable to feed themselves, to care for

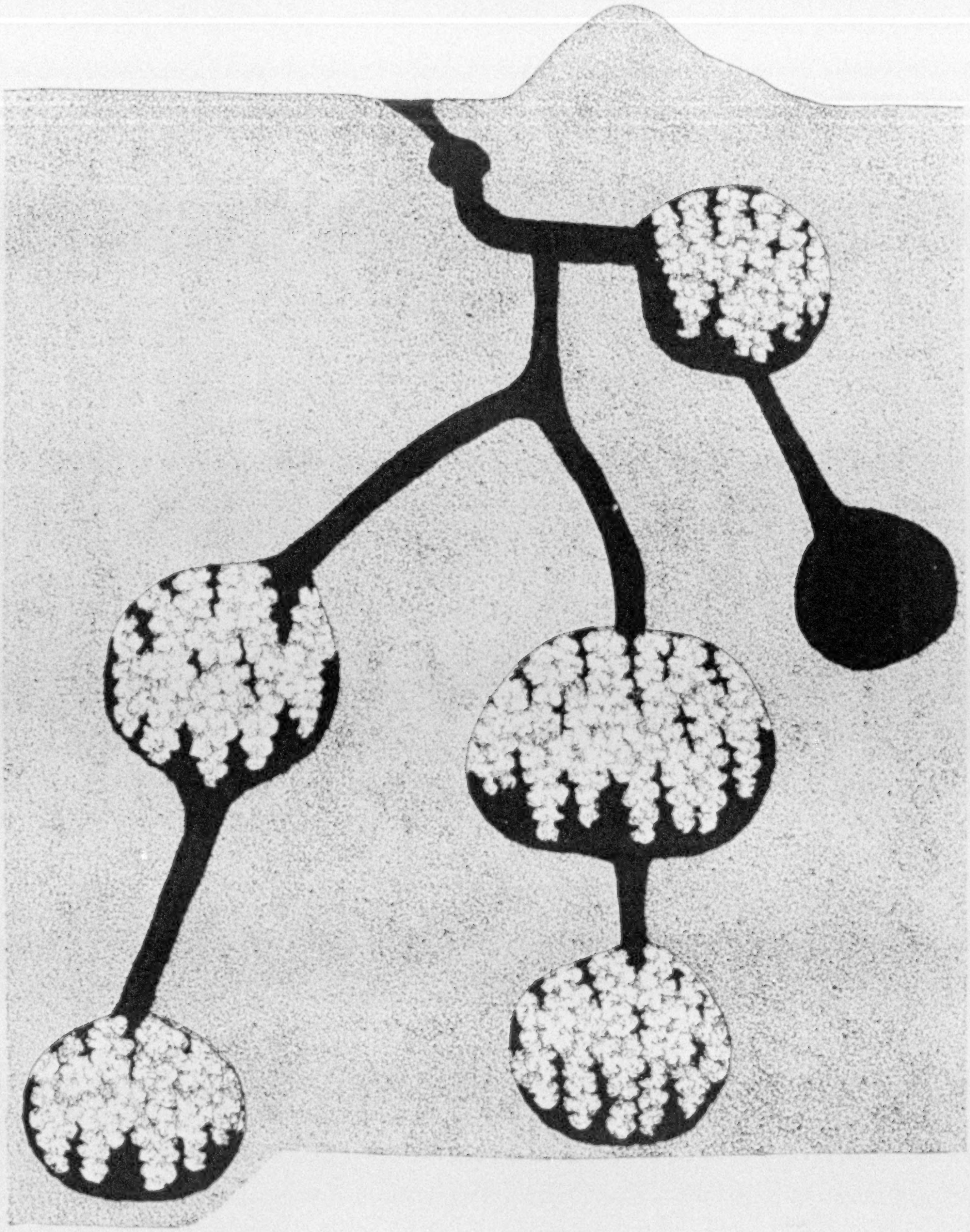
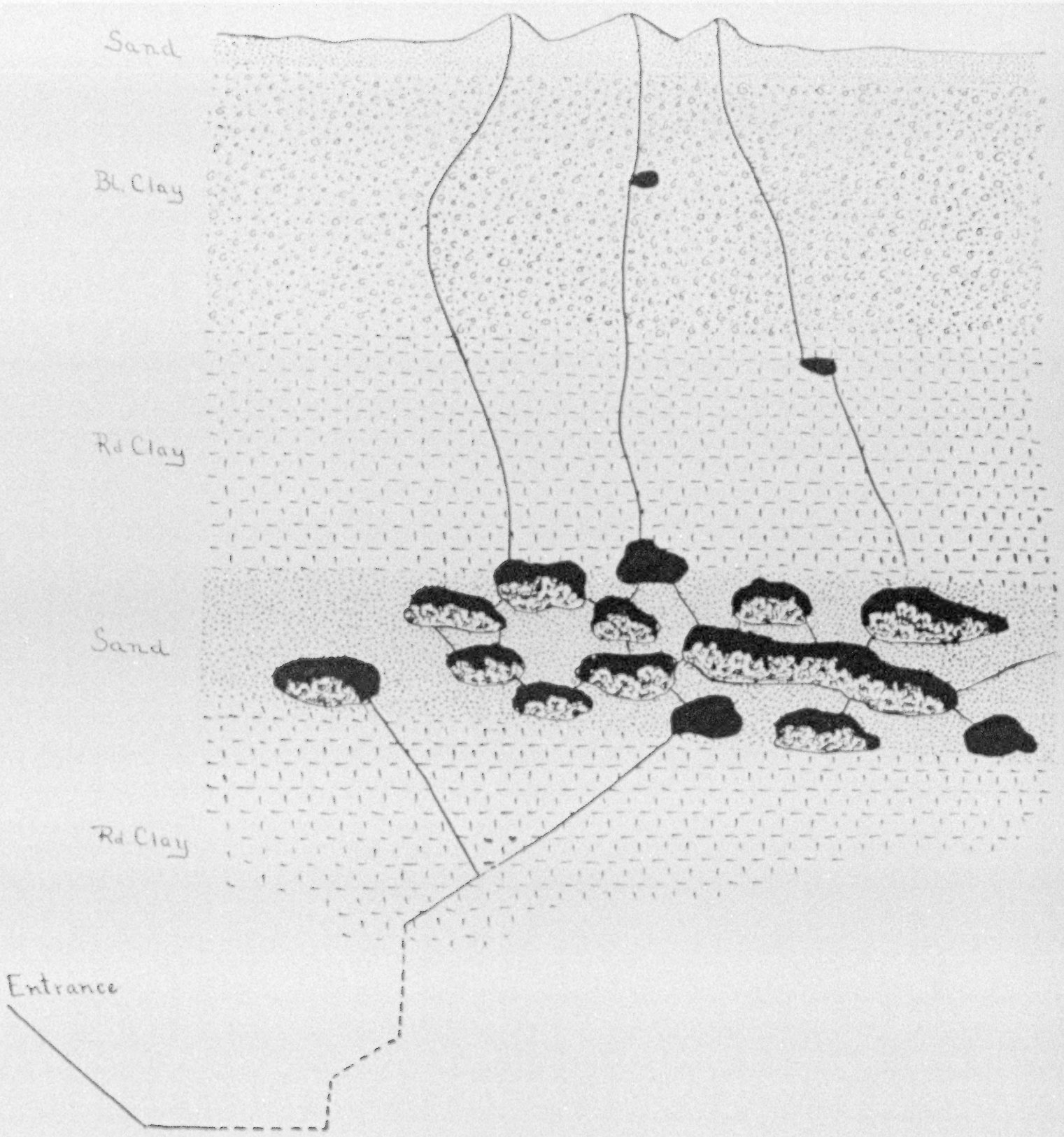


ILLUSTRATION OF THE GARDENS OF A FUNGUS-GROWING ANT (*Trachymyrmex obscurior*) OF THE SOUTHERN STATES

The figure shows near the surface the small original chamber formed by the queen, five chambers, with pendent fungus gardens, and a newly excavated chamber, in which the garden has not yet been started (see text, pages 737 and 738).



From a sketch by Messrs. A. L. Melander and C. T. Brues

NEST DIAGRAM OF THE TEXAN LEAF-CUTTING ANT (*Atta texana*).

The large chambers, with sponge-like fungus gardens on their floors, are situated in a stratum of sand under layers of red and blue clay and several feet below the surface, on which the nest craters have their openings (see text, pages 737 and 738).

XUM

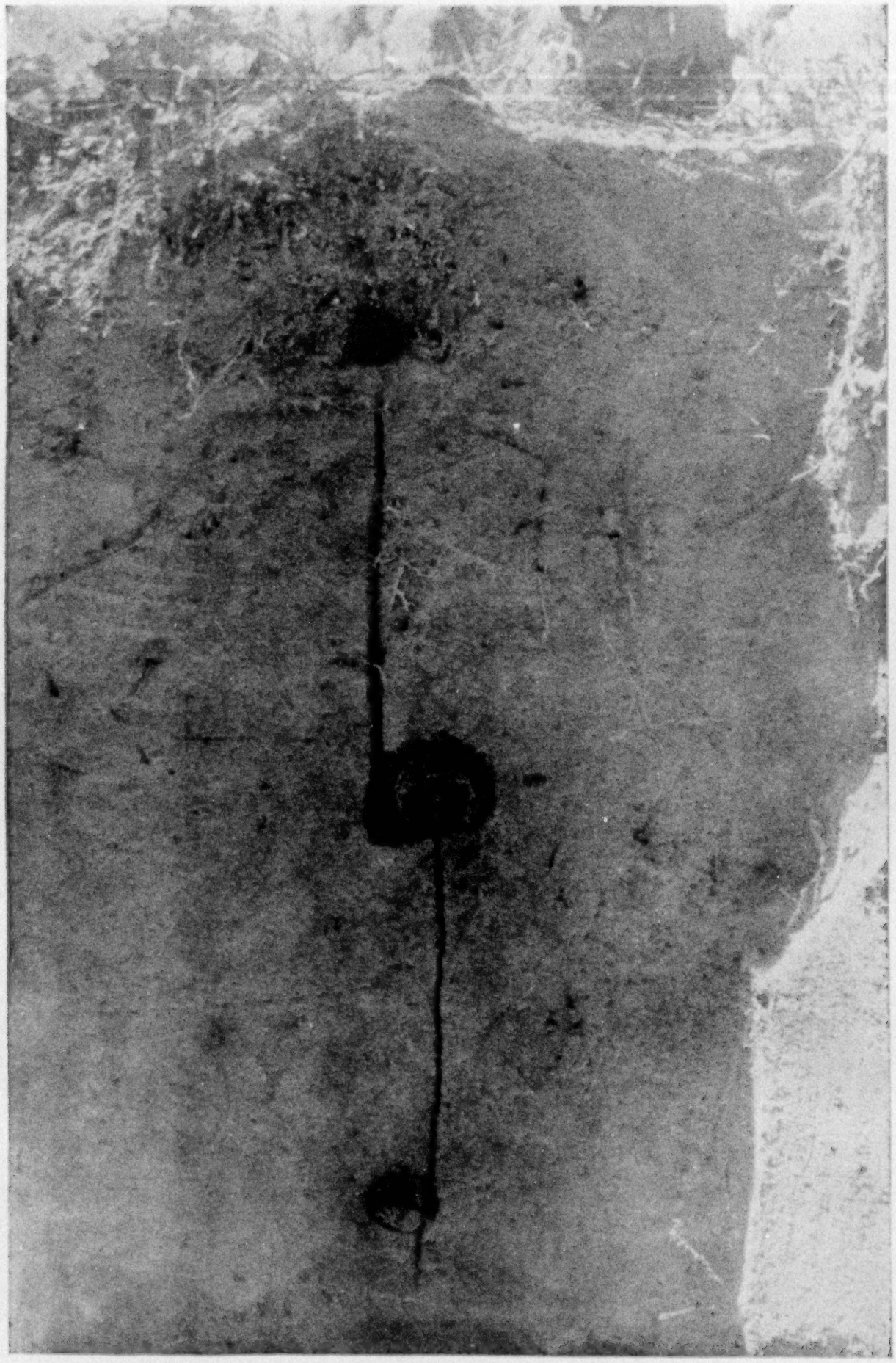


Photo by C. G. Hartman

A PHOTOGRAPH OF A SECTION OF THE NEST OF A SMALL TEXAN FUNGUS-GROWING ANT (*Mycetosoritis hartmani*)

Two of the three chambers of the nest, which is excavated in pure sand, contain pendent fungus-gardens. About one-fourth the natural size

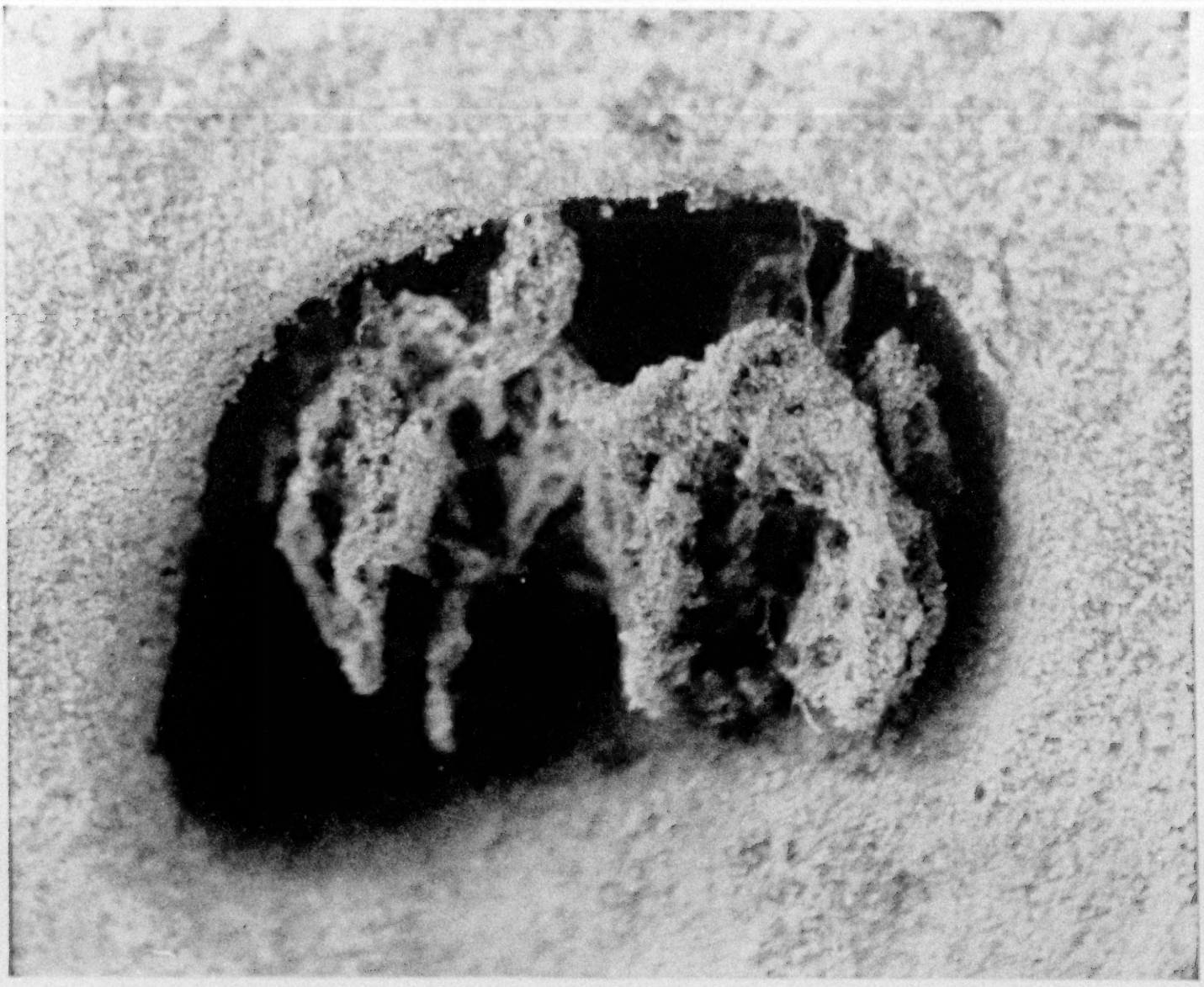


Photo by C. G. Hartman

NEST CHAMBER OF A SMALL TEXAN FUNGUS-GROWING ANT (*Mycetosoritis hartmani*)

The middle chamber of the preceding figure one-fourth larger than natural size, showing in the upper right-hand corner some of the rootlets to which the garden is suspended

their brood, or to excavate the nest, and are therefore compelled to keep kidnapping the young of the host species in order to secure the performance of these tasks. The other method is by completely suppressing the worker caste in the parasitic species, so that the queen after her adoption in the nest of the alien species can at once produce males and females within the host colony's lifetime, which is very short because the host queen has been eliminated.

These various methods of colony formation show that among ants the extreme adaptations of parasitism have for their sole object the securing of better opportunities of reproduction.

The restriction of reproduction to a few members of the colony brought with it, among other advantages, the usurpation of the nutritive and protective functions by a special caste, the workers, which, moreover, comprised the majority of the personnel of the colony. Later these functions were delegated to two subdivisions of this caste, the workers proper and the soldiers.

Among the special adaptations for the protection of the colony we may cite the development of the sting and of the various poisonous or malodorous secretions with which the workers spray or smear the bodies of their enemies, the enlarged mandibles of the soldiers, and above all the excavation or construction of the nest, which protects the colony both from its enemies and from excessive drought, cold, and heat.

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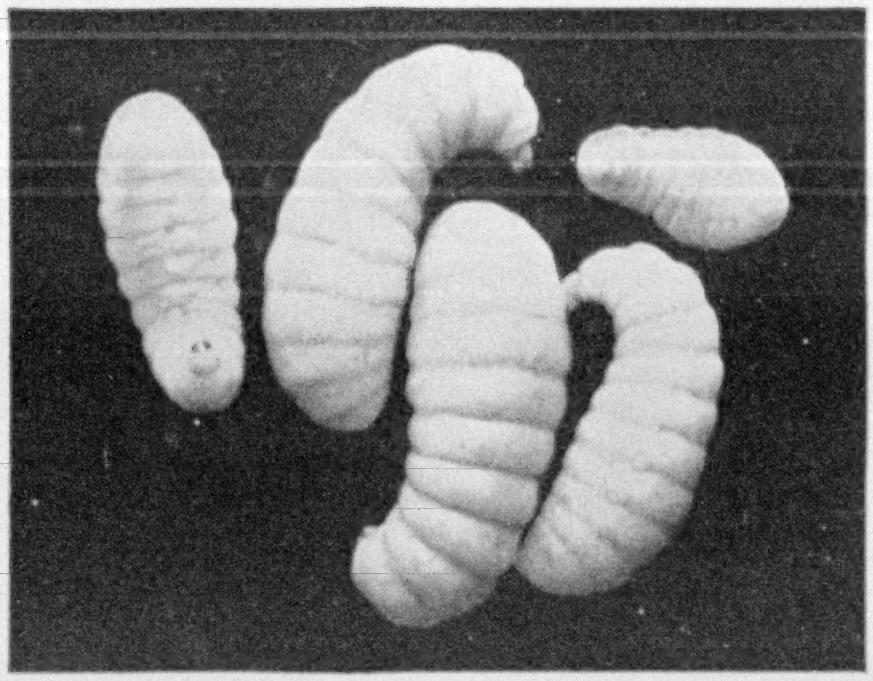

Photo by the Author

LARVÆ OF THE TEXAN AGRICULTURAL ANT (*Pogonomyrmex molefaciens*)

The brilliant white color and tensity of the skin in these grub-like creatures is due to the great accumulations of fat, which will be used, in part at least, during pupation in building up the body of the adult ant. Magnification about five diameters.

ANTS THAT BUILD INCUBATORS

Ants no doubt originally nested in the earth, and the majority of species still prefer this habitat. It was while living in this plastic material that they learned to prefer irregular galleries and chambers and to become great opportunists, in marked contrast with the social wasps and bees, which have never been able to depart from their habit of rearing their young in combs made of a refractory substance like paper or of an expensive secretion like wax.

The ants early discovered the great advantages of being able to carry their brood from place to place when danger threatened.

In connection with this free method of dealing with the brood, they were also led to add to the original subterranean nest a kind of tepidarium or incubator, in which the young could be placed during the warmest hours of the day for the purpose of hastening their development (see pictures, page 759). This incubator is the mound or dome of pebbles or vegetable detritus, which surmounts the subterranean nest of many of the more conspicuous species of North America and Eurasia, especially in mountain regions, where the summers are so short that the ants have to utilize every bit of mid-day heat in order to bring their young to maturity.

The mound is riddled with chambers and galleries and is not only fully exposed to the sun, so that its temperature is several degrees higher than that of the surrounding soil, but its slopes are often constructed in such a manner to catch the heat rays perpendicularly and form the most effective regions of the heavens. This orientation of the nests is indeed often so conspicuous and definite that they can be used as compasses (see pictures, pages 742, 759).

In the tropics where the soil is often saturated or flooded with water during the rainy season, and where devices for conserving the heat are quite unnecessary, many ants have learned to construct paper nests on the trees. Such nests superficially resemble the nests of wasps. They contain no combs, however, but only a maze of irregular, intercommunicating galleries and chambers. A few tropical species belonging to three different genera (*Ecophylla*, *Myrma*, and *Camponotus*) inhabit nests consisting in part at least of a fine silken web.

REPAIRING THE NEST WITH SILK

It was long a mystery how ants could manufacture silk, but it has been recently shown that the ants themselves do not spin the silk, but use their larvæ for this purpose. The process can be actually observed by making a rent in the wall of the nest and then following the movements of the ants under a magnifying glass. They separate into two brigades, one of which stations itself on the outside of the nest and draws the edges of the rent as close together as possible by pulling with claws and mandibles, while the other, inside the nest, moves the spinning larvæ back and forth across the gap till it is filled out with a dense felt-work of extremely fine silken threads (see picture, page 764).

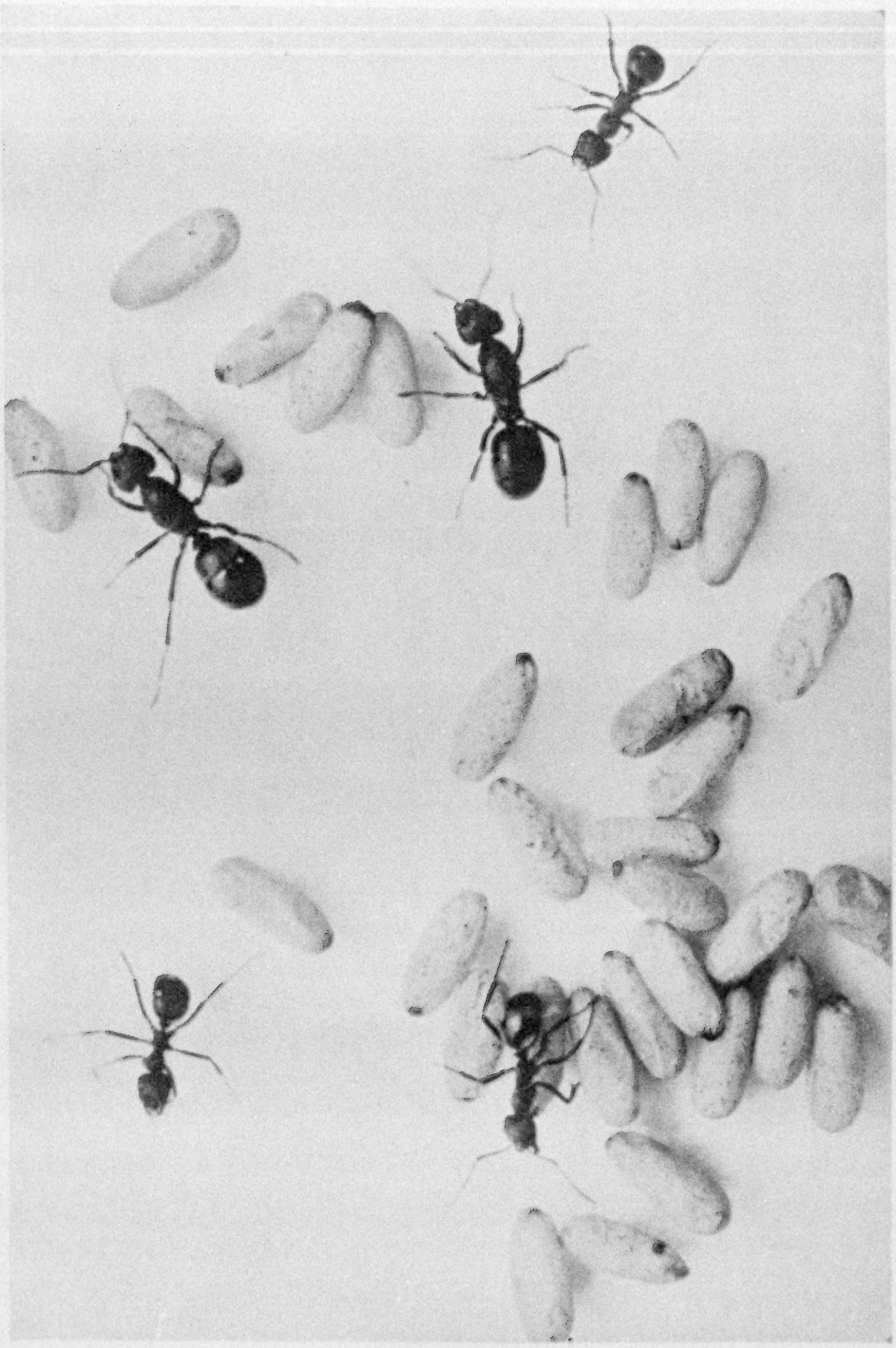

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

PORTION OF A COLONY OF AN AMERICAN SLAVE-MAKING ANT (*Formica sanguinea subintegra*) (SEE TEXT, PAGE 748)

Two females after the removal of the wings, three workers, and a number of worker cocoons, nearly twice the natural size

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

COLONY OF *Aphænogaster picea*, A COMMON ANT IN THE WOODS OF THE EASTERN STATES

The mother queen of the colony is seen at *a* in the lower right-hand corner of the photograph, a male at *b* in the upper left-hand corner

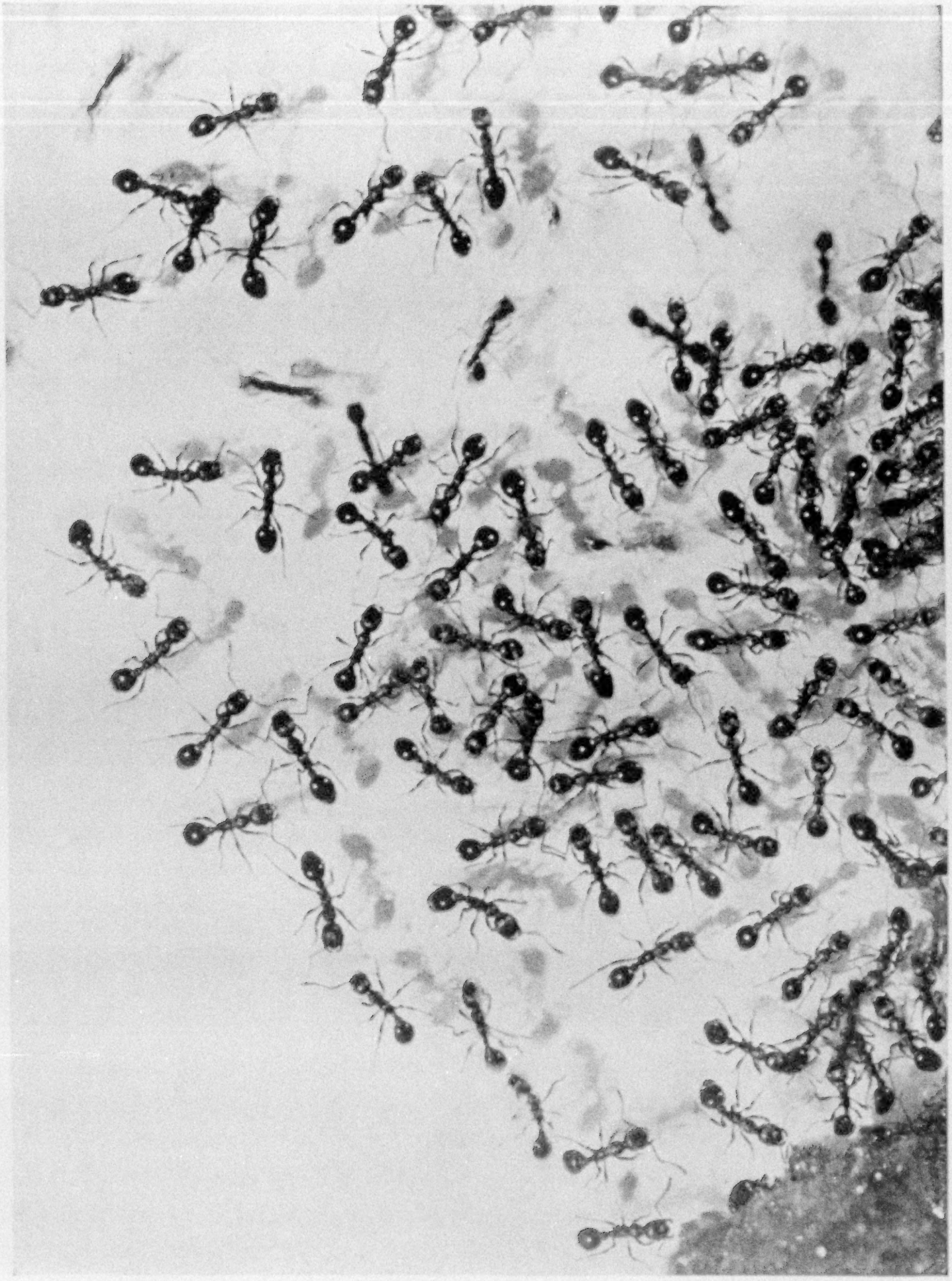

Photo by Mr. J. G. Hubbard and Dr. O. S. Strong

WORKERS OF THE COLONY OF *Aphænogaster picea*, SHOWN IN THE PRECEDING PICTURE

In this rather primitive ant the workers are all of the same size and shape, not polymorphic as in *Camponotus americanus* (see pages 735, 737, and 738) and many other species. Magnification about twice the natural size.

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LARGE NEST OF THE MOUND-BUILDING ANT (*Formica exsectoides*)

This nest, located at Scotch Plains, N. J., is 1 meter high, has a basal diameter of 3.25 meters, and a circumference of 10.21 meters

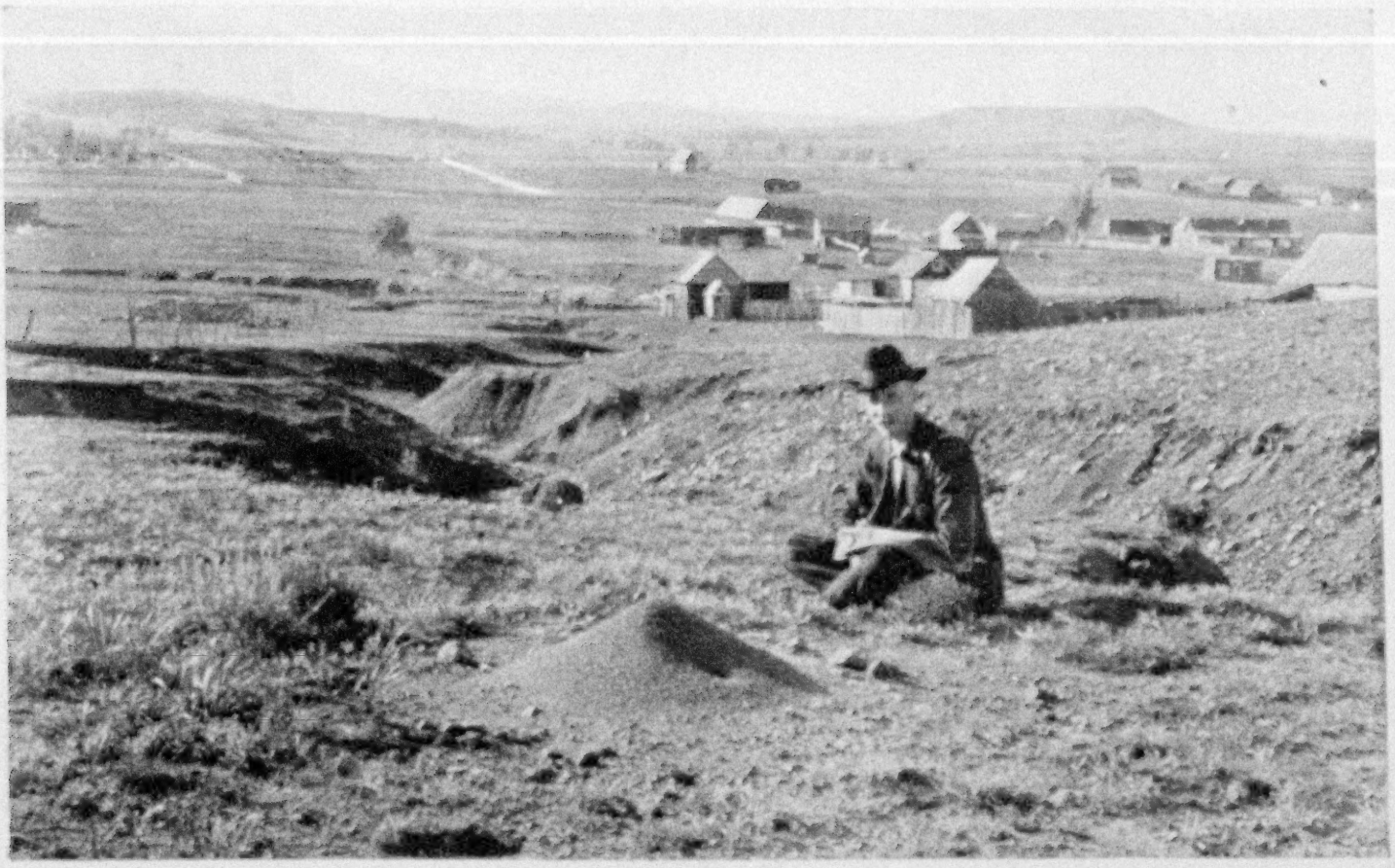
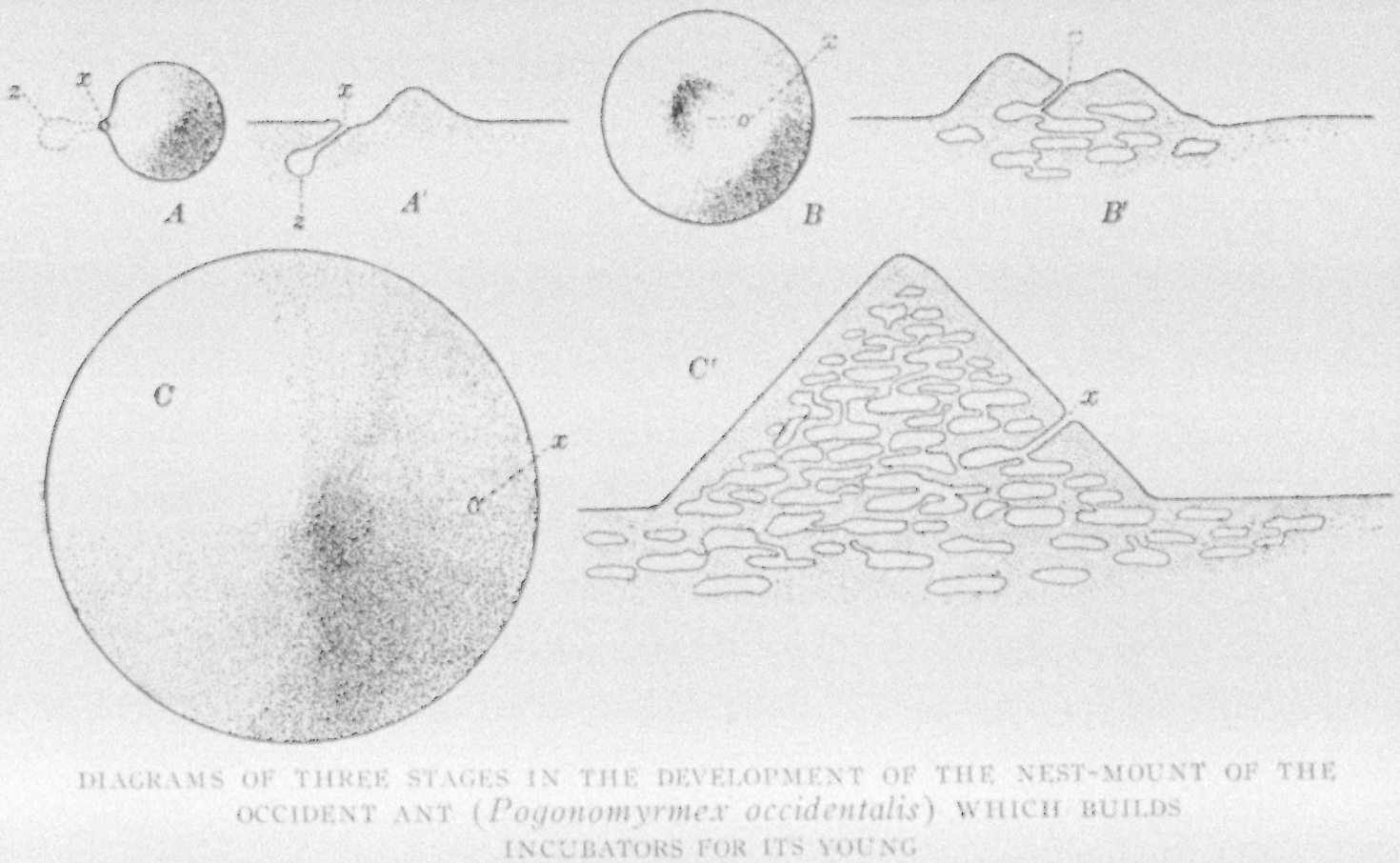


Photo by the Author

NEST OF THE OCCIDENT ANT (*Pogonomyrmex occidentalis*) WHICH BUILDS INCUBATORS FOR ITS YOUNG

On the Dry Plains at Las Vegas, New Mexico. The nest cone has its entrance near the base and nearly always on the east or south side. It is closed at night by the workers, and the advantage of having it in this position is to insure its being opened earlier in the morning when the warmth of the sun awakens the workers (see text, pages 746 and 747).



DIAGRAMS OF THREE STAGES IN THE DEVELOPMENT OF THE NEST-MOUNT OF THE OCCIDENT ANT (*Pogonomyrmex occidentalis*) WHICH BUILDS INCUBATORS FOR ITS YOUNG

A, small mound of earth thrown up by the queen when starting her formicary; *x*, entrance; *z*, first chamber; *A'*, same nest in section; *B*, crater nest (second year) formed by incipient colony; *B'*, section of same; *C*, dome of adult colony; *C'*, section of same showing galleries and chambers used for incubation of the young (see text, pages 746 and 747).

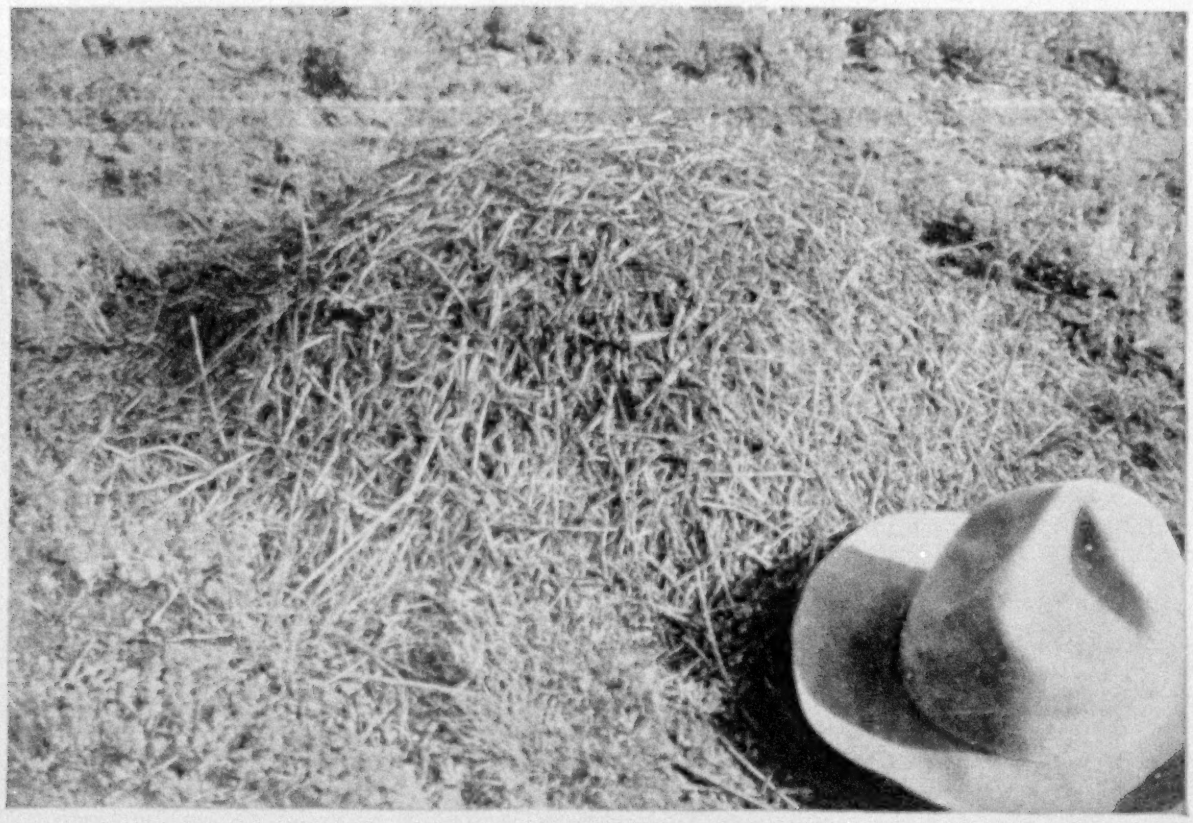
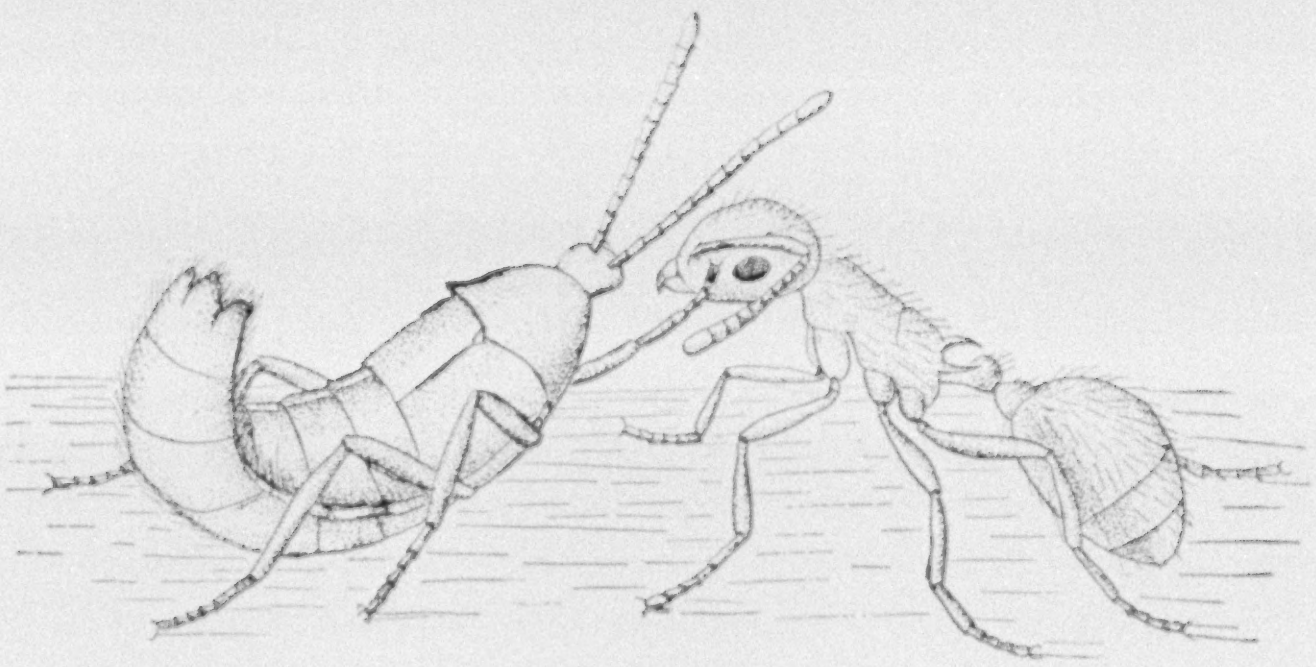


Photo by the Author

MOUND OF THE THATCHING ANT (*Formica rubiginosa*) OF COLORADO

The mound, which is made of coarse twigs and grass-blades, may be two or three feet in diameter



ANT GUEST OR PARASITE (*Atemeles*) SOLICITING FOOD FROM A WORKER *Myrmica* (AFTER E. WASMANN)

The beetle strokes the cheeks of the ant in order to induce her to regurgitate a drop of liquid food from her social stomach. Any insect which by means of its shape, odor, or behavior can delude the ants into feeling that it may be another out or one of their larvæ can secure free board and lodging in their nests (see text, page 748).

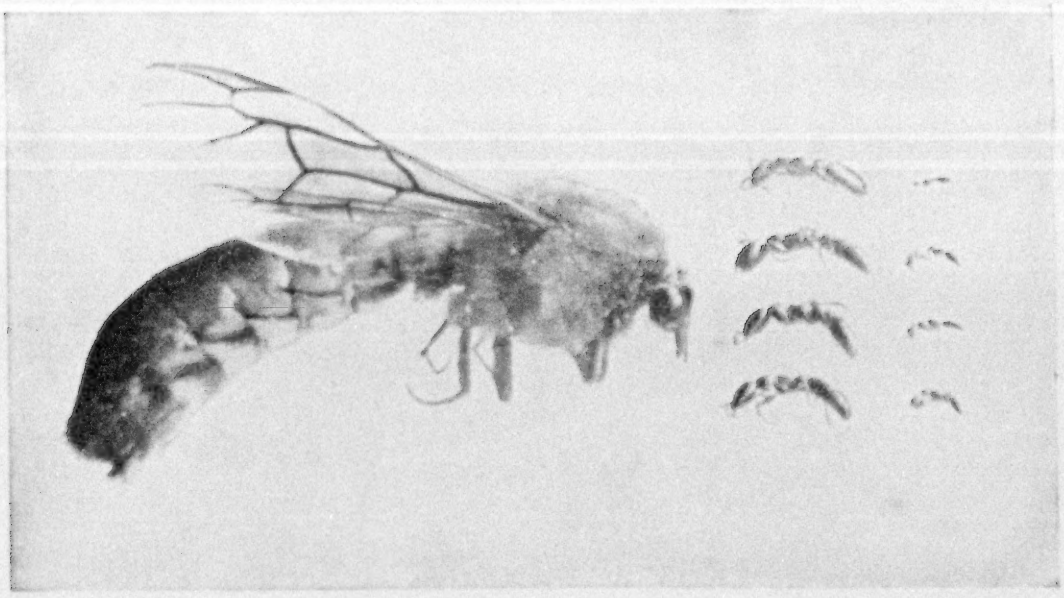


Photo by the Author

MALE AND WORKERS OF A SOUTH AFRICAN DRIVER ANT (*Dorylus fimbriatus*)

The male is a very large, hairy insect with large eyes; the workers are small and blind, but vary greatly in size.

The driver ants (Dorylii) in the tropics of the Old World and the allied legionary ants (Ecitonii) in the corresponding regions of America do not confine themselves to collecting dead or disabled insects. They move in long files over or immediately beneath the surface of the ground and capture myriads of living insects and their larvæ. So efficient are they in exterminating all kinds of vermin, including rats and mice, that they are welcomed into the houses, even if their owners are obliged to vacate for the time being.

In some countries the ants are regarded as useful allies in destroying the insect pests of plantations. According to Magowan, quoted by McCook (1882): "In many parts of the province of Canton, where, says a Chinese writer, cereals cannot be profitably cultivated, the land is devoted to the cultivation of orange trees, which, being subject to devastation from worms, require to be protected in a peculiar manner, that is, by importing ants from the neighboring hills for the destruction of the dreaded parasite. The orangeries themselves supply ants which prey upon the enemy of the orange, but not in sufficient numbers; and resort is had to hill people, who, throughout the summer and winter, find the nests suspended from branches of bamboo and various trees. There are two varieties of ants, red and yellow, whose nests resemble cotton bags.

"The orange-ant feeders are provided with pig or goat bladders, which are baited inside with lard. The orifices they apply to the entrance of the nests, when the ants enter the bag and become a marketable commodity at the orangeries. Orange trees are colonized by depositing the ants on their upper branches, and to enable them to pass from tree to tree, all the trees of an orchard are connected by a bamboo rod."

An interesting side-light is thrown on the various nutritive, reproductive, and protective devices in ants by the behavior of the insects that live as guests or parasites in their nests. Of these insects, called myrmecophiles, some 1,500 species have been described, a wonderful assemblage of creatures whose sole aim in life is to exploit the ants. They stay in the nests because these afford warmth, food, and protection. Some myrmecophiles feed on the larvæ and pupæ, or even on the adult ants, and some, known as true guests or symphiles, have developed glands that emit a redolent secretion which seems to fascinate the ants much as a catnip fascinates cats. The more highly developed of these true guests are fed and reared by the ants as if they were ant larvæ.

EVER READY HOSPITALITY

The only explanation of such extraordinary behavior towards parasites which eventually injure or destroy the colonies they infest must be sought in the inordinate fondness of the ants for their own brood and for one another. Observation and experiment have shown that any insect which, by means of its shape, odor, or behavior can delude the ants into feeling that it may be another ant or one of their larvæ, can secure free board and lodging in their nests (see picture, page 760).

Having discussed some of the more

NEST OF AN ARBOREAL BRAZILIAN ANT (*Azteca trigona*)

This nest consists of paper (carton) and is built around a branch of the trumpet tree (*Cecropia adenopus*). (Photograph from a specimen in the American Museum of Natural History.)

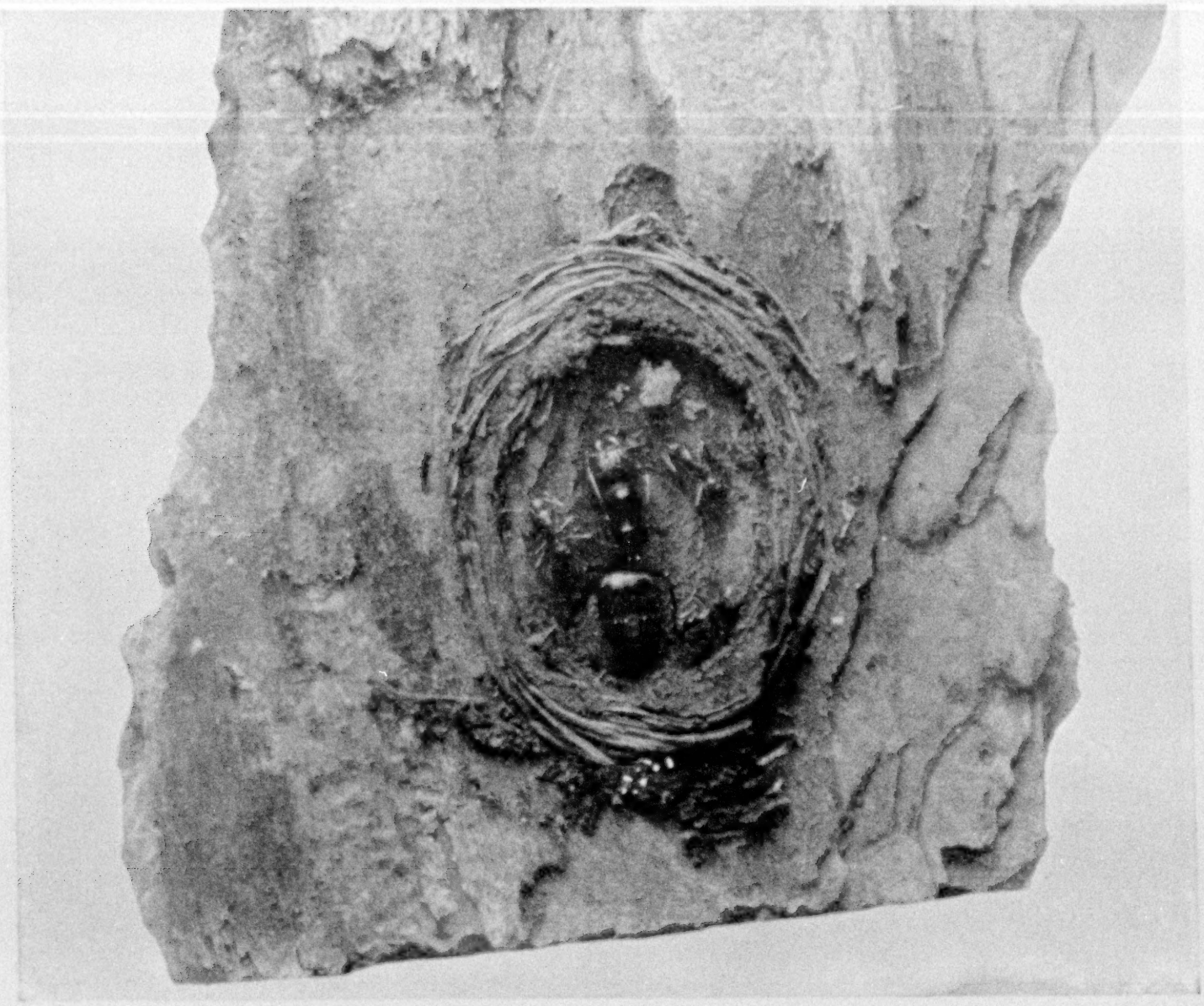


Photo by the Author

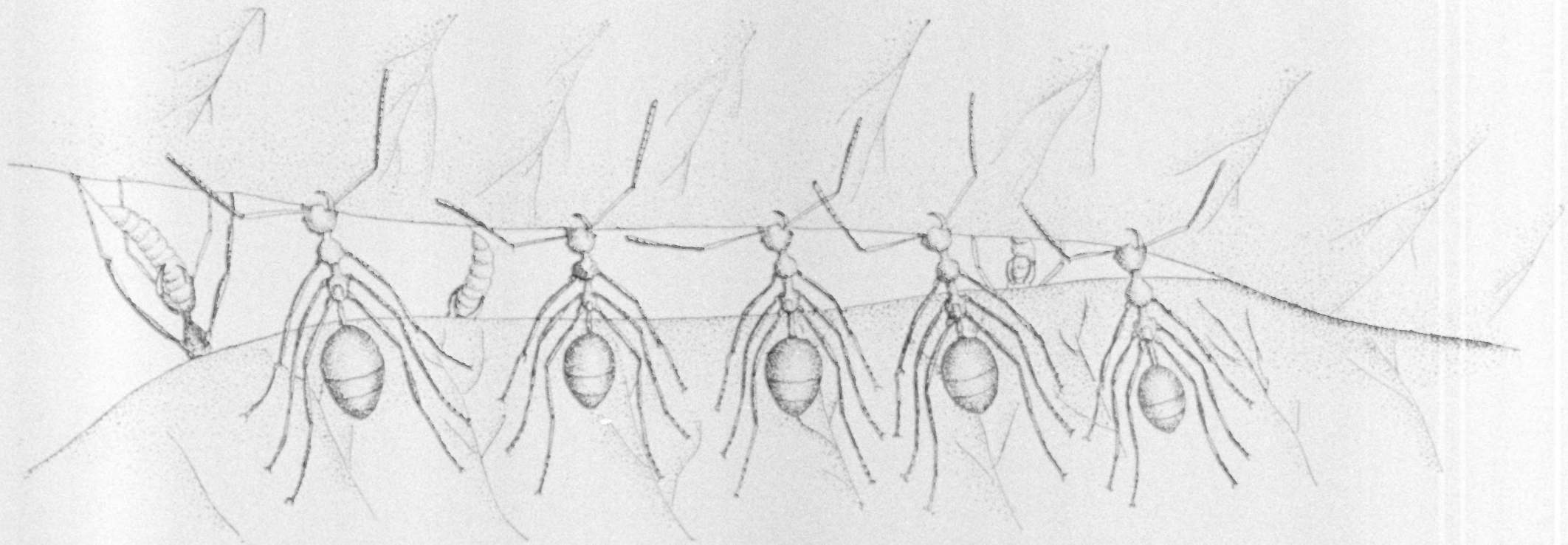
INCIPIENT COLONY OF CARPENTER ANT (*Camponotus pennsylvanicus*)

The queen has established her colony in the abandoned cocoon of a beetle (*Rhagium lineatum*) under pine bark, has reared a few small workers, and has started a second brood, represented by a small cluster of larvæ in the upper part of the chamber (see text, pages 741-742). In incipient ant colonies the queen mother takes no food often for as long a period as 8 or 9 months, and during all this time is compelled to feed her first brood of larvæ exclusively on the secretion of her salivary glands.

striking peculiarities which the ants have developed during the long course of their evolution, a word may be added in conclusion on the prospects of future developments. It must be confessed that these prospects are not very bright, for, strange as it may seem, there are no indications that these insects have made any considerable evolutionary progress since early Tertiary times.

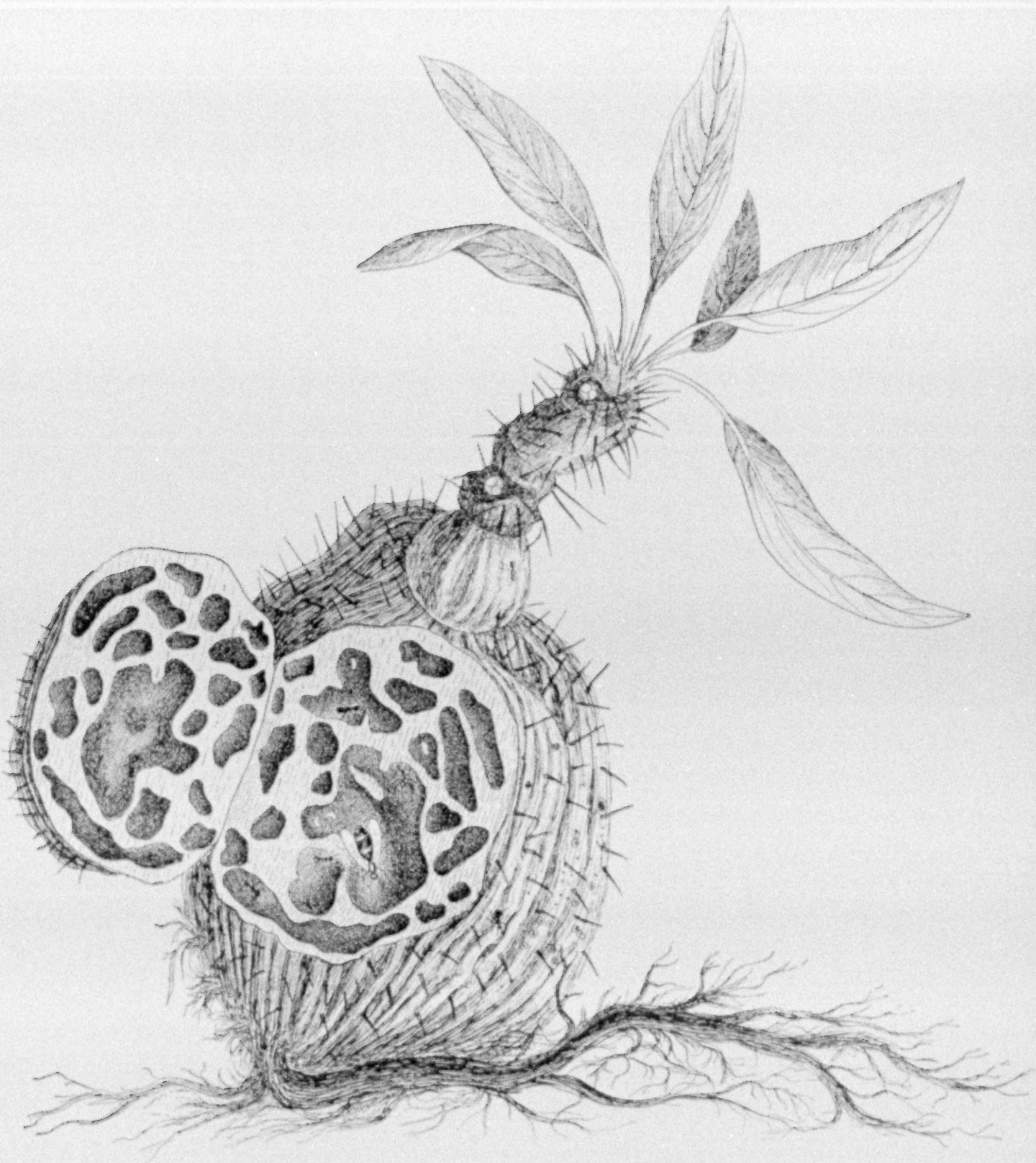
The exquisitely preserved ants of the Baltic amber, belonging to the Lower Oligocene formation, are in all respects like existing ants. All of them belong to existing subfamilies, most of them even to existing genera, and a few of them are practically indistinguishable from species inhabiting Europe today. That some of them were herders of plant-lice is proved by blocks of amber containing masses of ants mingled with the plant-lice which they were attending when the liquid resin of the Oligocene pines flowed over and embedded them. Possibly the soldier caste is a recent innovation, but the differentiation of the males, queens, and workers was as extreme and precisely of the same character then as now.

This seems to force us to the conclusion that all the great features of ant-life must have been established during the Mesozoic Age, and although many spe-



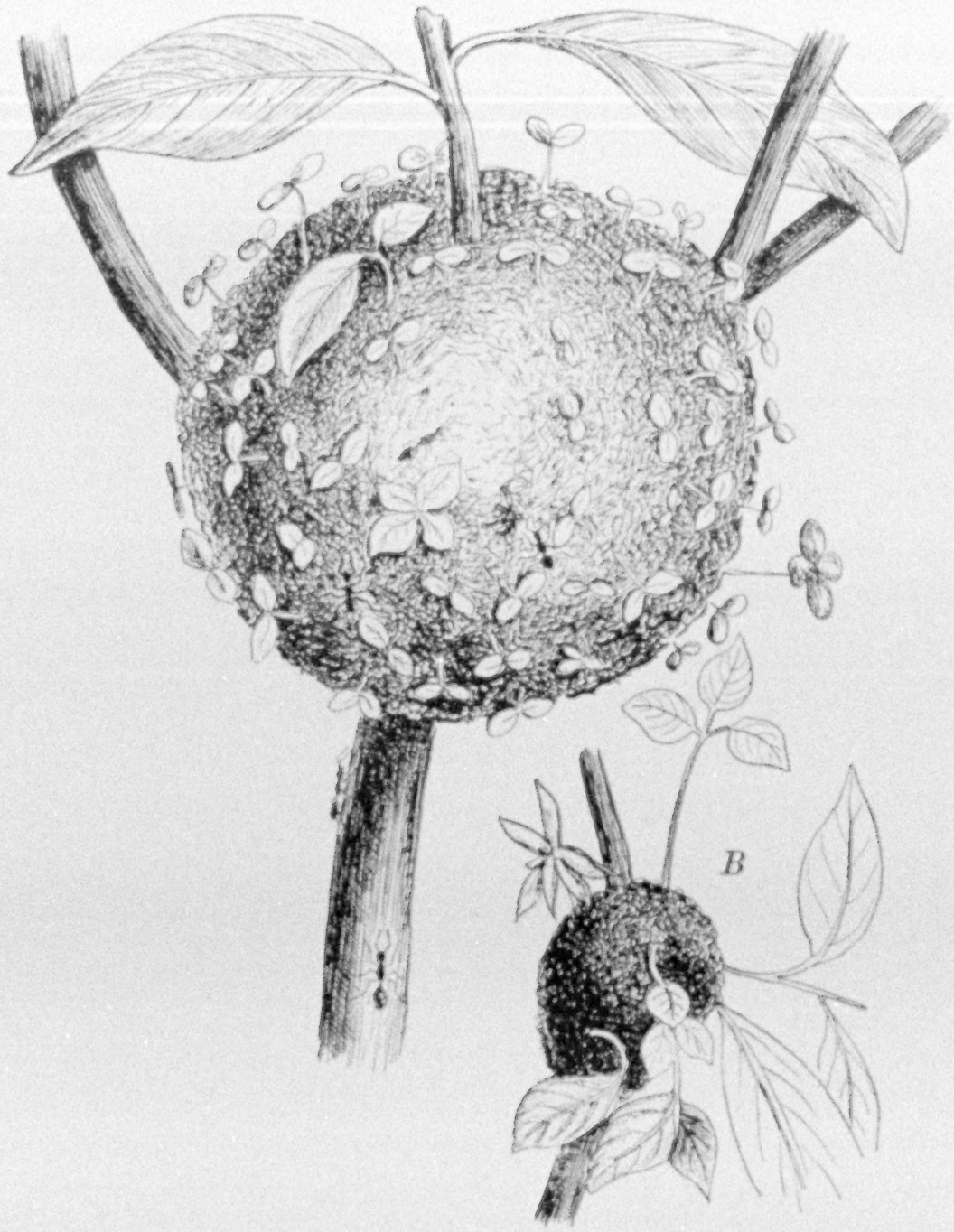
THE REPAIRING OF A RENT IN THE NEST OF THE RED TREE ANT (*Œcophylla smaragdina*) (AFTER F. DOFLEIN)

The nest is made of leaves, held together with a silken web. The figure shows the workers repairing a rent, one brigade of them being occupied in drawing the edges of the leaves together, while the others on the inside of the nest move the spinning larvæ back and forth across the gap (see text, pages 747 and 748).



AN EPIPHYTIC ANT PLANT (*Myrmecodia pentasperma*) OF THE BISMARCK ARCHIPELAGO (AFTER F. DAHL)

The large pseudobulb is filled with cavities, which are nearly always tenanted by ants (*Iridomyrmex cordatus*)



ANT GARDENS OF THE AMAZON (AFTER E. ULE)

A a large, *B* a small spherical, sponge-like mass of earth which is built around the axils of the branches of trees in the tropical forests and, according to Ule, is seeded by the ants with parasitic plants.

cies, subspecies, and varieties have since arisen and may yet arise, we must nevertheless admit that the future development of the group will probably be limited very largely or exclusively to a more minute differentiation of existing forms and a greater refinement of existing modes of behavior.

THE GRANDEST AND MOST MIGHTY TERRESTRIAL PHENOMENON: THE GULF STREAM

By John Elliott Pillsbury, U. S. Navy

THE subject of ocean currents is one that has engaged the attention of mariners and men of science for centuries. In all oceans there are movements of the water (other than that caused by the tides) which may be said to be due primarily to the prevalent wind.

Many branches of scientific inquiry are concerned in their examination, for they bear directly upon the dissemination and evolution of species and the deposit and structure of geological formation, while in the business world they enter as a factor in the price of everything carried afloat as well as in the safety of all those who travel by sea. The currents of the ocean too are the great transporters of the sun's heat and moisture from the torrid zone, to temper the climate of more polar regions.

In the two great oceans, the Atlantic and the Pacific, there is to be found both north and south of the equator, and also in the Indian Ocean, a similar circulation, that is, a general westerly movement in the tropics, a flow toward the poles along the eastern shores of the continents, an easterly set in the temperate zones, and a current toward the equator along the western shores. It thus becomes a grand circular movement, some parts being quite slow, and other parts very swift; sometimes there may be a temporary interruption in the slower portions, or perhaps even a reversal, but taken as a whole the movement is continuous (see map, page 768).

In the North Atlantic Ocean the currents are probably more pronounced than in either the Pacific or the Indian Oceans. Without entering upon a discussion now as to the causes of ocean flow, or of any particular current, a brief description of the main streams will not be out of place, for they are all connected more or less intimately with our Gulf Stream.

The equatorial current is usually described as being a broad band of water moving across the Atlantic in the tropics. The portion of this current situated south of the equator is divided into two parts upon meeting the eastern salient of South America, Cape St. Roque. One branch turns south toward the Antarctic, while the other is forced to the westward along the shores of Northern Brazil and the Guyanas, and is called the Guyana coast current. The equatorial current north of the equator has an almost uninterrupted progress until it reaches the Windward Islands, but a portion of it also impinges against the Guyana Coast and thus augments the volume of that current.

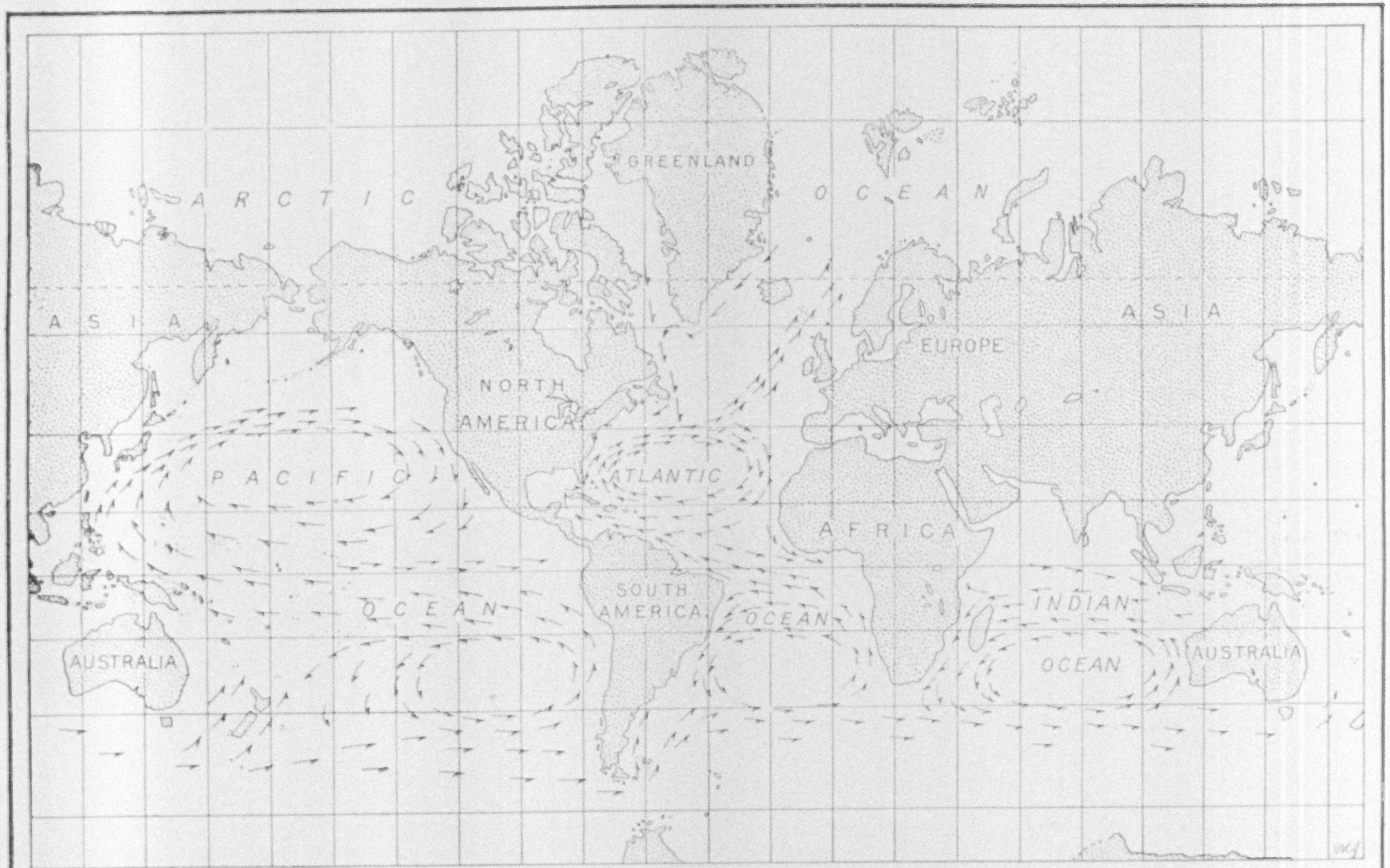
At the Windward Islands both are united, and a portion of the flow enters the Caribbean through the various passages, crosses it to the Yucatan and Honduras coasts, and thence into the Gulf of Mexico, from which it issues through the Straits of Florida as the Gulf Stream. Passing onward toward Europe it is augmented in volume by a part of the north equatorial current that sweeps along outside the West Indian Islands and the Bahamas, and while this current is slow in movement in comparison to the Gulf Stream itself, it doubtless carries a much greater number of heat units to help warm up northern Europe.

The Gulf Stream, or rather the combined flow mentioned above, divides as it meets the resistance of the Eastern Continent, one branch flowing south along the African coast, while the other proceeds northward into the Arctic toward Spitzbergen and Franz Joseph Land.

THE IMMENSITY OF THIS OCEAN RIVER

The Gulf Stream is probably the grandest and most mighty of any terrestrial phenomenon. Its waters are characterized by a deep indigo blue color of great clearness and high temperature. It can be penetrated by the eye to considerable depths, and generally its meeting with the less saline polar waters can be at once distinguished.

It is difficult for the mind to grasp the



MAP OF THE WORLD, SHOWING THE PRINCIPAL OCEAN CURRENTS

immensity of this great ocean river. The Straits of Florida at its narrowest point is about 40 miles wide and observations here numbered between three and four thousand, surface and subsurface. A calculation of the average volume of water passing in one hour gives the enormous sum of 90 billion tons. If this one single hour's flow of water could be evaporated, the remaining salts would require many times more than all the ships in the world to carry it.

When one is on board a vessel, floating upon its waters, one is not as much impressed at the power and grandeur of this wonder of nature as he is when he stands before a towering mountain, an immense iceberg, or a fall of water such as Niagara, but when one remembers that the mighty torrent, speeding on hour by hour and day by day in a volume equal to all the largest rivers in the world combined, carrying its beneficient heat to temper the climate of continents, one begins to realize that of all the forces of the physical world none can equal this one river of the ocean.

THE INFLUENCE OF THE GULF STREAM ON THE COLONIZATION OF AMERICA WAS VERY GREAT

It is interesting to note in the history of the Gulf Stream how great its influence has been on the fortunes of the New World. Before the discovery of America, strange woods and fruits were frequently found on the shores of Europe and off-lying islands. Some of these were seen and examined by Columbus, and to his thoughtful mind they were convincing evidence of the fact that strange lands were somewhere to the westward. These woods were carried by the Gulf Stream and by the prevailing winds from the American continent, so that in part, the stream is responsible for the discovery of the New World.

Ponce de Leon, while on his famous search for the Fountain of Youth, made the discovery of this great stream. After his failure to find, on the coast of upper Florida, the means of cheating death, he turned to the southward and skirted the shore for hundreds of miles, thus stemming the current.

Referring to this in his journal he describes that they found a current that, though the wind was good, they could not stem. It seemed that their vessels were going fast through the water, but they soon recognized the fact that they were being driven back in spite of the strong and favorable wind. Two of the ships near the coast were able to anchor, while a third, being in deeper water, was "soon carried away by the current and lost from sight, although it was a clear sky."

The first one to traverse the Gulf Stream from the Gulf of Mexico was Antonio de Alaminos, who had been with Columbus on his last voyage, and had been with Ponce de Leon among the Bahamas and along the coast of Florida from St. Augustine to Tortugas. Later he was in chief command of the fleet with Cortez in Mexico, and when it was desired to send dispatches and presents to Spain he was chosen as the one most able to carry out the nautical part of the mission. He sailed from Mexico, and in order to avoid foreign enemies and domestic rivals, took the route north of Cuba and through the Straits of Florida into the Atlantic.

The influence of the Gulf Stream in the colonization of America was very great. The division of the English colonies into New England and Virginia was probably in part due to the routes by which they were reached. Vessels bound from England to New England crossed the North Atlantic outside the limit of the Gulf Stream, or in a feeble adverse current. They had the advantage too, of crossing the Newfoundland Banks and of being able to surely replenish their provisions by fishing.

This voyage, however, much as the advantages might be either by the shorter distance or the gaining of food, was not thought to be practicable with a vessel bound to the Southern Colonies. They sailed south to the trade-wind region, through the Caribbean and around Cuba, thence following the Gulf Stream to their port.

The Dutch adopted this passage to the Hudson, so that really Nantucket Island became the dividing line between the two

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voyages; a difference of 100 or 200 miles in destination caused a difference in the length of the passage of about 3,000 miles.

BENJAMIN FRANKLIN PUBLISHED THE FIRST CHART OF THE GULF STREAM

The whalers of New England were the first to gain a fairly accurate knowledge of the limits of the stream between Europe and America by following the haunts of the whales, which were found north of one line and south of another, but never between the two.

Benjamin Franklin heard of their experiences, and also how the coasting vessels from Boston to Charleston, South Carolina, would take sometimes three or four weeks to make the voyage south, while the return trip would often be made in a week. Then his attention was drawn to the fact that English packets with American mails were two or three weeks longer on the voyage to America than American merchant ships.

Franklin investigated the question and published a chart in 1770 for the benefit of the mail packets, but its information was discredited by the English, and before it came to be generally known and used, the war of the Revolution was on, and Franklin, knowing the advantage of the knowledge of the limits of the stream would be to British naval officers, suppressed it all he could until hostilities ceased.

The name of "Gulf Stream" was first suggested by Benjamin Franklin because it issues from the Gulf of Mexico. While it is only a part of the grand scheme of ocean circulation, and the Gulf of Mexico is in reality only a stopping place, as it were, for its waters, this name is generally applied to the current now as it was given by Franklin—that is, the current coming from the Gulf of Mexico and spreading abroad over the North Atlantic.

In the large funnel-shaped opening between Cuba and the western extremity of the Florida reefs the current is somewhat erratic, but by the time Havana is reached it has become a regular and steady flow. As it rounds the curve of the Florida shore, the straits contract and the current then practically fills the banks from shore to shore and reaches almost to the bottom, which at this point has a greatest depth of nearly 3,000 feet. I say almost because in its variations in velocity sometimes it does actually reach the bottom, but at other times it does not.

As it leaves the Straits of Florida its direction is about north, but it gradually changes and follows a course approximately parallel to the curve of 100 fathoms depth until it arrives off Cape Hatteras, and maintains about the same width as when it issued from the Straits of Florida. From this point it starts on its course to Europe. It has lost something in velocity as well as in temperature, and as it journeys to the eastward it gradually diminishes in both, until at last it becomes a gentle flow.

On this part of its course it passes not far from the Grand Banks of Newfoundland, where it is met almost at right angles by the great Labrador current, bringing down from the Arctic a stream of cold water, pack ice and icebergs, and which has recently been the cause of such an appalling disaster in the loss of the *Titanic*. This current, passing along the eastern shores of Newfoundland, bearing its freight of ice, sends part of its current southward and westward around Cape Race; part overflows the banks on a general southerly course and part passes to the southward along the eastern side of the banks.

When this cold current meets that of the Gulf Stream of much higher temperature, the former underruns the latter. The shallow-draft pack ice, being no longer under the influence of the polar current, is carried to the eastward by the warm Gulf Stream current and soon disappears, but the deep-draft bergs are still under the influence of the lower current running south, as well as of the surface current running east, and so they continue on until well into the Gulf Stream, sometimes reaching the thirty-ninth parallel, which is nearly 200 miles south of the southernmost point of the Grand Banks.

This ice, together with the fog, which usually accompanies the meeting of currents of considerable differences in tem-

perature, has compelled steamship companies to adopt lanes of travel and to make a detour around the region of danger. That the western-bound track was shaving dangerously near the limit of ice in the spring, when bergs are numerous, has been shown, and it is probable that the new lanes now used which lie further south will be permanently adopted during the ice period.

THE CAUSE OF OCEAN CURRENTS

The theories as to the cause of ocean currents have been many. Columbus thought the stars, the air, and the waters of the sea all had the same motion around the earth from east to west and declared that the force of the equatorial current had washed away the land and thus formed the Windward Islands.

Toward the end of the 17th century the belief seemed to be that all ocean circulation was maintained by means of subterranean passage or abysses. A current, upon meeting land, descended into the earth and ran through a tunnel to the other side of the obstruction.

Strange to say, the writer was called upon in recent years to examine a paper written by a gentleman whose theory was somewhat similar to the above. He believed that all mountain ranges were simply the visible evidence of a tunnel conveying water from one ocean to another, the Rocky Mountain tunnel being the conduit by means of which water was transported from the Arctic to the Gulf of Mexico to form the Gulf Stream. Another theory was that the tropical sun evaporated so much water that the African Coast current ran to fill up the hollow so formed.

In recent times the course of currents has been laid to rivers and the Gulf Stream chiefly to the Mississippi. In actual fact about 2,000 such rivers would be required.

Some eminent men have attributed currents to the revolution of the earth, others to the differences in the density of the ocean at the equator and at the poles.

Franklin's theory, which has many advocates at the present day, was that the winds produce the current by the air moving over the surface of the water, and he illustrated this theory by the following: "It is known that a large piece of water, 10 miles broad and generally only 3 feet deep, has by a strong wind had its water driven to one side and sustained so as to become 6 feet deep, while the windward side was laid dry." As will be seen later, this is a well-taken example of the force of the wind in causing the Gulf Stream, but it does not quite show the whole of the truth.

None of these theories were based upon direct evidence by observations in the Gulf Stream, but all were inferences drawn from temperature of the water, from laboratory experiments, from the drift of vessels, or from reasoning based upon opinions of what ought to be.

Much time and labor has been devoted toward attempting to define the limits of ocean currents and their velocities. Columbus on his first voyage, when nearing his final land fall, was trying to find the depth of the water one day, when he noticed that the line inclined to the southwest, from which he concluded that the surface was moving faster than the lower stratum which contained the weight on the end of the line.

Franklin endeavored to use the thermometer to define the limits of the polar and tropical waters, and hence the current. This method is often correct, for without doubt tropical water is warmer than that coming from the poles, but it has been found that at times the warm tropical water may be blown by the wind over and onto the polar stream and then partake of its motion or, as in the Labrador current, underrunning the warm water of the Gulf Stream. Temperature is not a sure indication of how the current may be setting.

Almost all governments at one time issued instructions to their naval officers and requested the coöperation of the officers of their merchant marine to keep a record of the temperature of the surface water, and by the compilation of these data the supposed limits of most ocean currents were placed upon the charts.

A method of determining the velocity of the currents has been in use since the introduction of comparatively accurate navigation. A vessel is moved at sea, by

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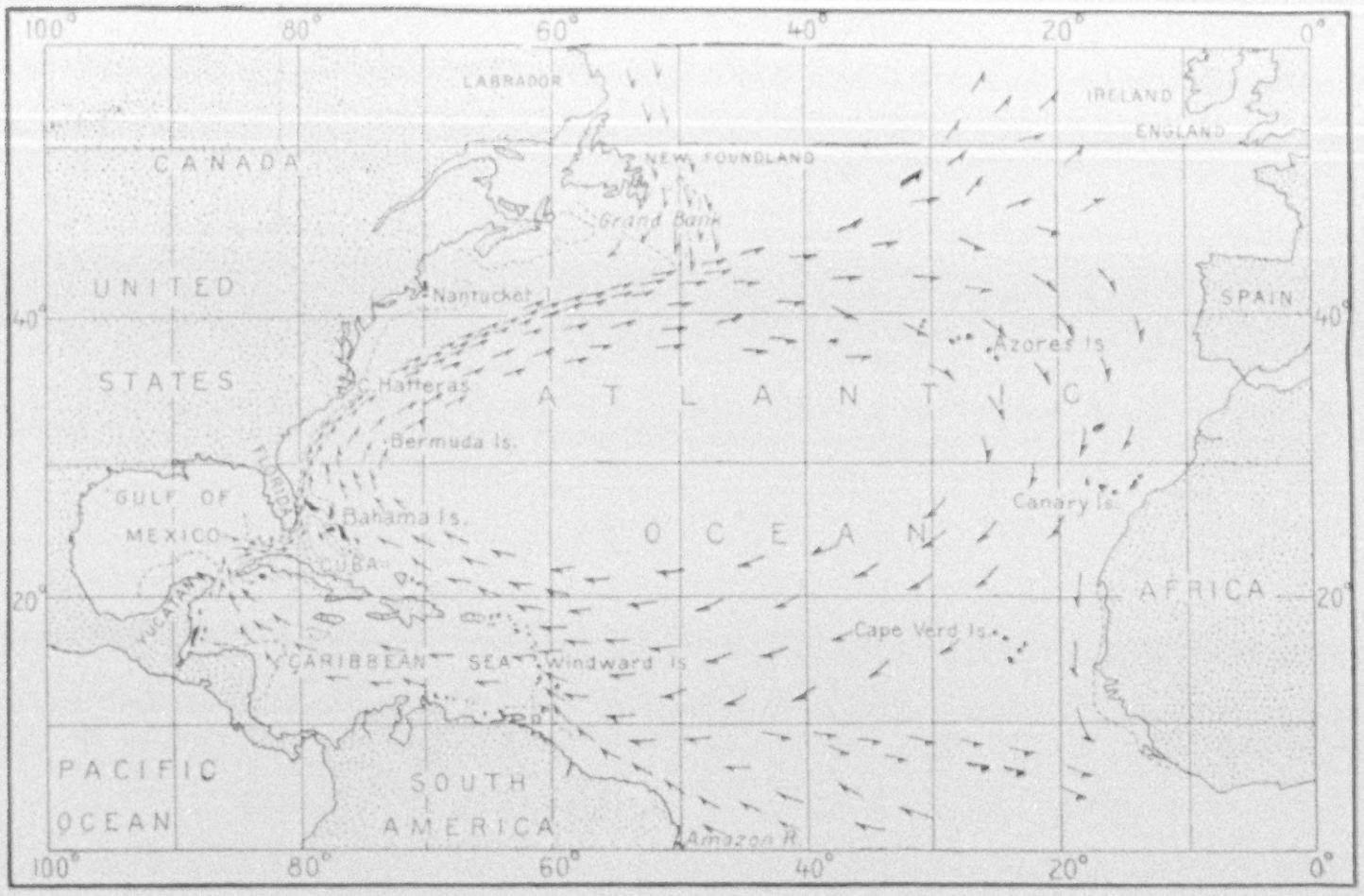


OUTLINE MAP SHOWING GENERAL DIRECTION OF THE GULF STREAM AND OTHER CURRENTS IN THE NORTH ATLANTIC OCEAN

the wind or by engines, as nearly as possible on a given compass course and for a given distance as ascertained by the log or by the engine revolutions, but she is deflected from that course and distance by winds, waves, bad steering, etc., *and by currents* to an unknown amount. By astronomical observation the captain ascertains the position of his ship from time to time, and the difference between this position and the supposed position is assumed to give the direction and velocity of the current affecting the ship during the interval.

Still another method has been practiced, and even now is favored by some for determining the flow of currents. Bottles or floats of various descriptions are thrown overboard from vessels at sea, each one containing a paper on which is written the date and position at which it is put afloat, and a request printed in various languages asking the finder to mark the date and locality where found and forward it to some official.

This method is of but little real value. The bottle is tossed by the waves and driven by the wind. If it is picked up on the shore, there is no means of knowing how long it has been traveling at sea and how long idle on the beach and when it is found, all that it tells is that it has journeyed from one point to another, but by what route it is impossible to tell.

Floats put adrift in the Atlantic between Newfoundland and the Azores have been found distributed, some of them years afterward, all the way from Iceland and Norway to the West Indian Islands and on the shores of the Gulf of Mexico.

The importance of a knowledge of the Gulf Stream to commercial interests was early recognized by the Congress in the passage of an act authorizing the Coast Survey to include it within the scope of its work, and later, authority was given to examine the Sargasso Sea (the body of water lying in the center of the grand circular movements of currents in the Atlantic) and also the mate to the Gulf Stream in the Pacific, called the Kuro-Shiwo, or Black Stream, of Japan, which pours its warm waters toward our western shores to temper its climate, in the

same way that the Gulf Stream does for Europe.

The superintendent of the Coast Survey, Prof. A. D. Bache, between 1844 and 1860 caused thousands of thermometrical observations to be taken on lines extending across the stream, from Key West to well beyond Hatteras, reasoning on the line of Benjamin Franklin's studies, that temperature alone could define its limits, and that the warmest water within these limits would be the axis or the swiftest current.

He found, however, that there were bands or streaks of warm and cold water in the stream, the cause of which was attributed to irregularities in the bottom over which it flowed, but this was based upon erroneous measurements of the depths, for in later years, with wire sounding lines instead of rope, the bottom has been found to be nearly even.

For ascertaining the relative velocity of the Gulf Stream between the surface and subsurface on a given line, trials were made by floating a single can almost submerged on the surface and a pair of cans, one on the surface and the other suspended by a cord at a given depth below. If both were started together, one being only influenced by the surface current and the others being influenced by the surface and the subsurface as well, the retarding or accelerating effect of any difference in velocity might be determined.

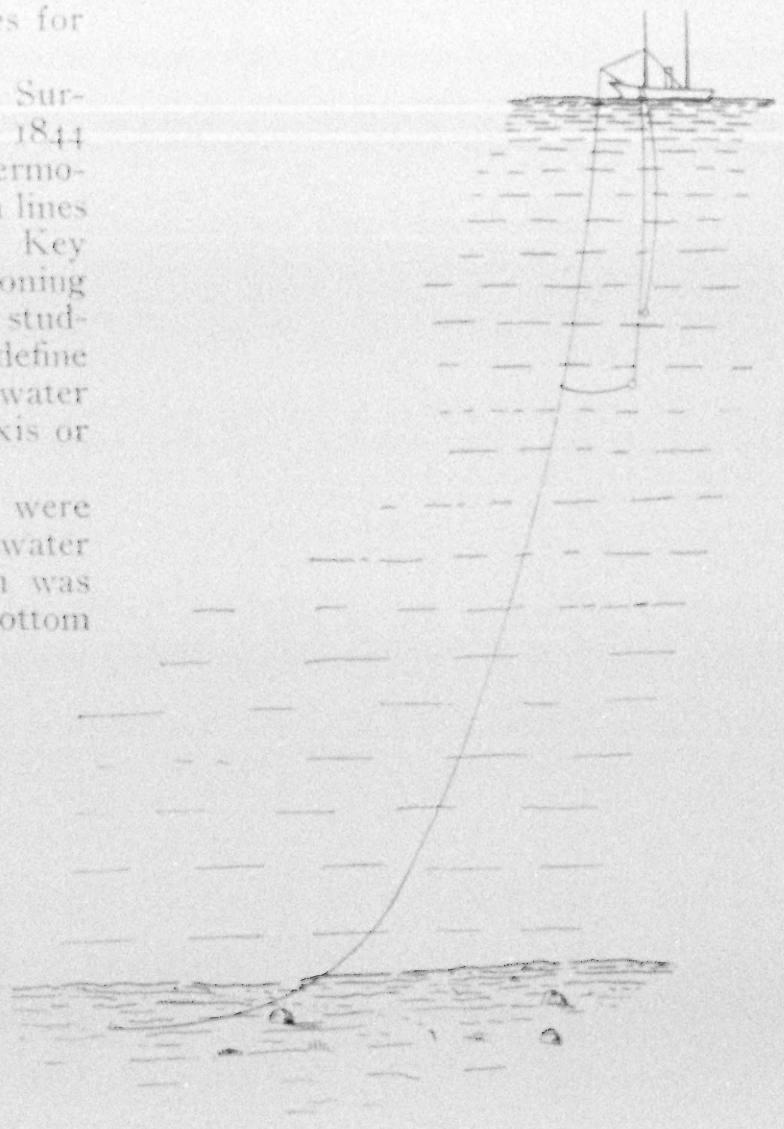


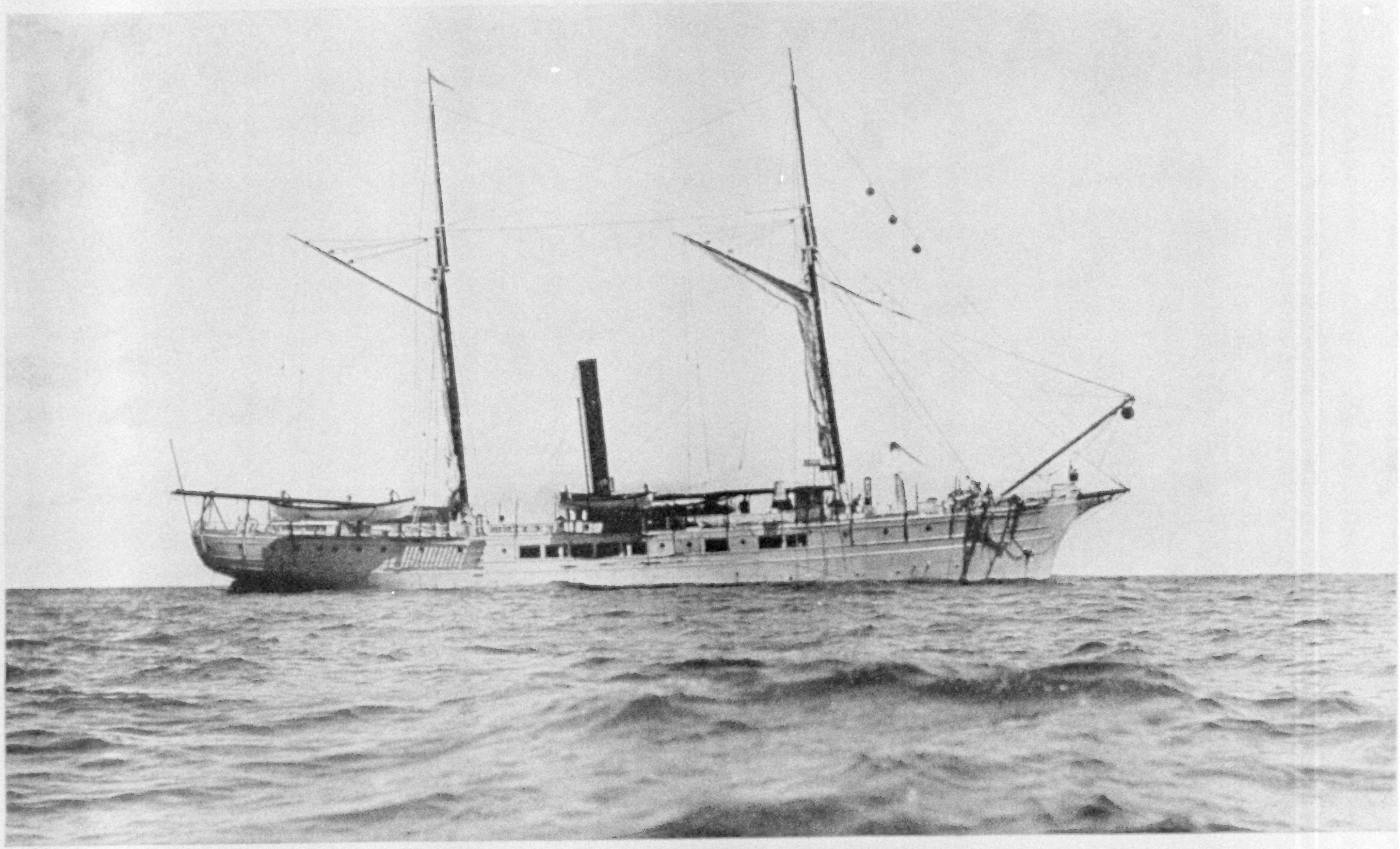
DIAGRAM SHOWING THE METHOD OF OBTAINING THE CURRENT OBSERVATIONS ON BOARD THE "BLAKE"

The current meter at the end of the wire on the right, slides down another larger wire having at its end a heavy leaden weight, which in turn is restrained from being swept astern by the force of the current by a long line secured to the anchoring rope.

In 1883 the Coast Survey Office decided to attempt to anchor a vessel in the Gulf Stream and to actually measure the amount of water flowing past. It was thought that this might be accomplished by the use of wire rope instead of a hemp cable or chain, both on account of its strength and flexibility, and also because it could be made in great lengths. The first trial at anchoring in the Gulf Stream was made by the little Coast Survey schooner *Drift*, but with no steam power to handle the wire rope anchoring line the difficulties were great. The result of this first attempt was the detail of a Coast Survey steam vessel, the *George S. Blake*, for the Gulf Stream work.

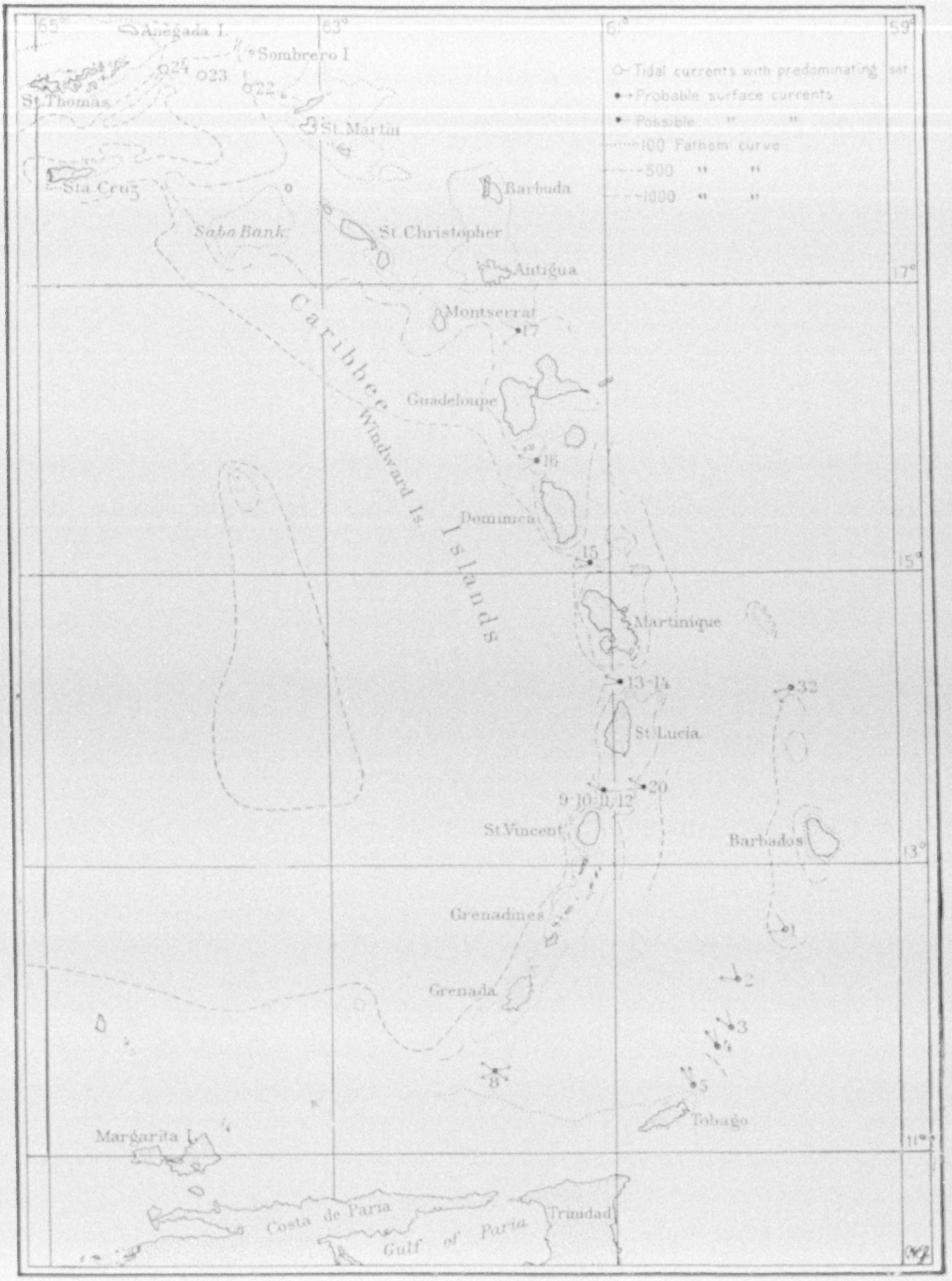
A new departure was then made from the ordinary method of anchoring in very deep water. A great length of wire rope (over 4½ miles) was carried on a large iron reel or spool. A powerful steam-engine, running a winch, lowered and raised the wire rope with its anchor, while another engine revolved the spool. A special arrangement of rubber buffers was applied to the anchoring rope, whereby the sudden strain, due to violent pitching of the vessel, was reduced to a minimum. By this system the *Blake* was able to anchor in almost any depth of water, and did anchor in depths of more than two miles many times.

To gain a knowledge of the laws governing the flow of any current, it is neces-



THE COAST SURVEY STEAMER "BLAKE" AT ANCHOR IN THE EQUATORIAL CURRENT, 60 MILES NORTH OF BARBADOS, IN 1100 FATHOMS OF WATER

The trade winds were temporarily interrupted. The ship was riding to the current coming from the east, although, as will be seen from the pennant at the masthead, the wind was from the west. When this photograph was taken the ship was anchored at Station 32, shown on map, page 775.



DIRECTION OF THE CURRENTS IN THE PASSAGES OF THE WINDWARD ISLANDS

The numbers indicate the record number of the anchorage whether occupied once or many times. The ship was anchored at Station 32, north of Barbados, when the photograph (shown on page 774) was taken.

sary to ascertain its direction and velocity not only on the surface, but below. The surface current is the one affecting the ship on its course, but it is also the most affected by changes in the local wind, which may be only temporary, while the vast body of flowing water maintains its direction, but feebly influenced by the slight surface changes.

An instrument was therefore designed by which the lower currents could be measured as well as the surface. It consisted of a rudder free to take the direction of the current, a compass needle which of course pointed to the north, and an apparatus for registering the flow. Upon hoisting the instrument all of these were locked at once, and upon its reaching the surface the angle between the rudder and the compass gave the direction, and the reading of the register showed the velocity.

Observations were usually made with the current meter at depths of 3½ fathoms, 15, 30, 65, and 130 fathoms, and at times to 150 and 200 fathoms, the instrument remaining at each depth during a period of 30 minutes.

The investigation began with these appliances in the narrowest parts of the Straits of Florida (between Fowey Rocks, which is near Miami, and the Bahamas) in order to find out the characteristics of the stream at a point where it would perhaps be least influenced by abnormal forces. After two seasons at this point the research was extended to the western part of the straits and to the passage between Yucatan and Cuba to gauge the water entering and leaving the Gulf of Mexico. Afterward, the equatorial current and the flow into the Caribbean between the islands were examined in order to compare what may be called the source of the Gulf Stream with the outlet as it leaves the Straits of Florida for the Atlantic. The stream off Cape Hatteras, the flow outside the Bahamas, and also south of Nantucket were all examined.

Some of the results of the investigation were surprising. The volume of the stream in 1 hour's flow has been mentioned, but the most valuable discovery was that it changes its velocity daily and monthly, and that predictions can be made as to the times of these variations. As the tides change in height on the coast, so the current changes in velocity in the ocean. The equatorial current along the South American coast runs fastest about 6 hours before the moon crosses the upper meridian; between Cuba and Yucatan the maximum is 10 hours before, and in the Straits of Florida off Fowey Rocks it is 9 hours.

These variations at certain times in the month amount to more than 3 miles per hour in some parts of the stream and at other times in the month may be less than 1 mile per hour.

During the month there is another change taking place following the changes in the declination of the moon north and south of the equator. Two or three days after the moon has passed the equator the maximum velocity of the stream is nearest the middle, but which it never reaches; it is always to the left of the middle, and two or three days after the moon's highest declination the maximum is well toward the left-hand edge of the stream.

Accompanying these changes the temperature of the stream fluctuates. At one time during the month, also varying with the declination of the moon, the direction of the currents, particularly the lower ones, incline slightly toward the axis of greatest velocity, while at other times they run more nearly parallel. This causes an intermingling of the warm surface with the colder water of the lower strata.

WHAT CAUSES THE GULF STREAM?

The various theories as to what causes the Gulf Stream have been given, but it seems that while Franklin's ideas are nearest correct, they are not complete. In the tropical regions there is a steady movement of the air from east to west known as the trade winds. South of a certain line situated near the equator these winds flow from a southwesterly direction, while north of the equator they come from a more northeasterly direction. The winds are not always strong, nor are they constant in direction, but they do not vary much, and then only for brief periods.

Winds blowing over the surface of the water induce a current in the latter due to friction. At first it is only the merest skim that moves, but gradually the motion is communicated from layer to layer until at last, if the wind is long continued as in the trade wind region, the movement extends to lower depths, 300 or 400 feet, or perhaps more.

These trade wind currents meet finally, the partial barrier of the islands forming the eastern part of the Caribbean, and a portion of the flow escapes through the passages between them. From here it continues its course across that sea until it reaches the obstruction of the Honduras and Yucatan coasts, from which it escapes by the easiest route, which is into the Gulf of Mexico.

It has been found, however, that the water entering the Caribbean by this means is not more than one-half of the amount which flows through the Straits of Florida from the Gulf of Mexico, and the other half is supplied from a source which does not come under the head of a measurable current. *The other source is the wave caused by the wind.* Every ripple carries a certain amount of water in the direction toward which it is flowing, irrespective of the current caused by its friction, and when the waves become large, tons of water are hurled from the crest into the trough every time the wave breaks.

In a large area like the Caribbean, having a comparatively constant wind blowing over its whole surface, this action is practically a simultaneous movement of its surface waters to the westward and a continual escape of the water heaped up at the obstruction offered by the land into the Gulf of Mexico, through the Straits of Florida, and into the Atlantic.

The Gulf Stream would be little felt on the coast of Europe did it not receive a great addition to its volume of heat when en route. This is by means of a gentle flow from the northeast trade-wind current that passes outside the Caribbean Islands and the Bahamas. The surface temperature of this outside current is about the same in its passage along the West Indian Islands as the Gulf Stream in the Straits of Florida, but it is less violent in its movements and there is less intermingling of its upper and lower waters, so that it arrives off Cape Hatteras with a much higher temperature than that of the more turbulent Gulf Stream.

THE GULF STREAM HAS NOT CHANGED ITS COURSE

Newspaper items are frequent that the Gulf Stream has changed its course, and to its supposed erratic movement is laid the blame of every abnormal season on our Atlantic seaboard. Gulf weed is seen up toward Nantucket, for example, and so the Gulf Stream must have changed its course in that direction.

The fact is this gulf weed originates in the Sargasso Sea and is transported chiefly by the break of the waves. Some of it enters the Gulf Stream and may be carried by it to beyond Hatteras and further east, but the fact of meeting it in strange regions is not so much an indication of a current as it is that the wind has caused a sea which has thrown the weed to leeward. Any strong southerly gale to the eastward of Cape Hatteras will strip the little gulf weed remaining in the Gulf Stream at that point and carry it toward the Nantucket shores.

The same influence of the wind to transport the water without an accompanying current is seen at Key West. With a southerly wind the clear water of the Gulf Stream is thrown into that harbor in spite of an ebb tide, and it is often accompanied by fragments of gulf weed, but upon a change of wind from the northward (which is from the Gulf of Mexico) the harbor waters soon cloud up.

Quite recently the overwhelming *Titanic* disaster, which was due to icebergs on the border of the eastern extension of the Gulf Stream, has led to the theory that the stream was feeble and had not been flowing with its usual strength and so the bergs were farther south than usual. Of course, there are periods of heat and cold—one year may vary noticeably from another—and perhaps an abnormal amount of heat transported to the Arctic regions some years ago by the

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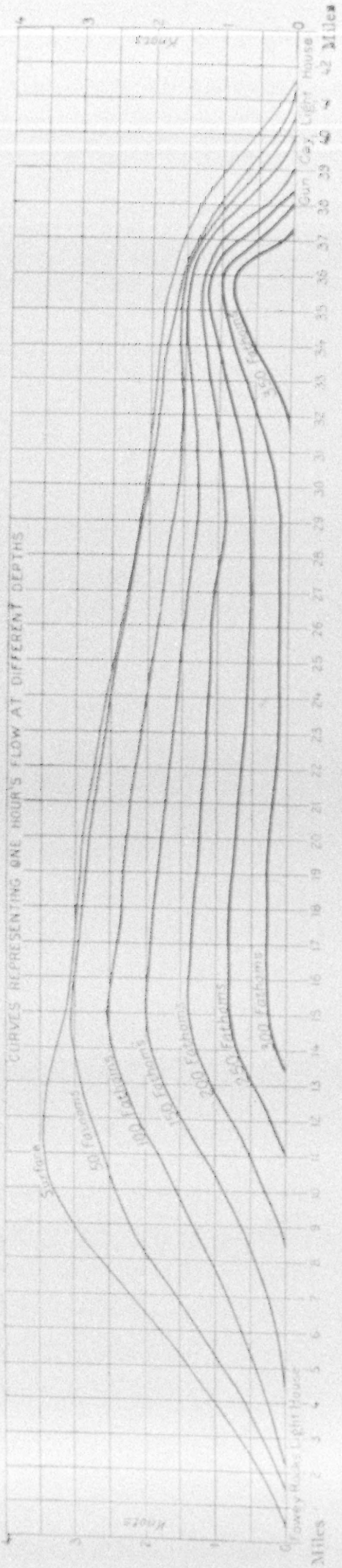


DIAGRAM SHOWING AVERAGE RATE OF FLOW OF THE GULF STREAM AT VARIOUS DEPTHS

stream may have been the cause of some of the bergs in the Atlantic this year, but when it is remembered that heavy ice from the Arctic takes anywhere from one to probably two or three years to make the journey to the steamers' tracks one cannot trace the increase or decrease in quantity or size of the bergs to the Gulf Stream.

Doubtless the stream varies in velocity at different seasons of the year because the trade winds vary periodically in strength and direction. In the winter months, when the northeast trades are stronger, they blow from a more northerly direction and at the same time do not extend to as far a northern latitude as in the summer. During the latter period they have a direction more nearly toward the west, and although weaker in force probably contribute more water to the Gulf of Mexico and hence to the Gulf Stream than do the winter winds.

These changes in the winds, however, are felt in the Gulf Stream by a gradual increase or decrease in its speed some time after, the maximum yearly strength, for example, coming in October, while the maximum trade-wind influence is in July and August.

A temporary or a local increase or decrease in the force of the trade winds would have but little effect on the Gulf Stream, because the current is due to the average condition of the wind over an area of hundreds of thousands of square miles, and this average does not change materially year by year.

Sometimes a low barometer in the Gulf of Mexico, accompanied by an abnormal high on the southern Atlantic coast, will cause a reverse flow on the sides of the stream in the Straits of Florida for a short time, but the *vis-a-tergo* of the great mass of water quickly reëstablishes the normal current.

There is every evidence that the Gulf Stream is governed absolutely by law in all its variations; its course through the ocean is without doubt fixed; its fluctuations are by days, by months, by seasons, or by years, but they do not vary materially one year from the other. So we may conclude, of all the physical forces on this earth that are subject to any variations at all, the great ocean currents are most immutable.

ELEPHANT HUNTING IN EQUATORIAL AFRICA WITH RIFLE AND CAMERA

By Carl E. Akeley

With Photographs by the Author and Copyrighted by Carl E. Akeley

ONE evening in Uganda, when rather discouraged after a day of unsuccessful effort to locate elephants, we suddenly heard the squeal of an elephant far to the east. The squealing and trumpeting increased in frequency and distinctness until in an hour's time we realized that a large herd was drifting slowly in our direction. By eleven o'clock they had come very close, some within two hundred yards of camp, and on three sides of us. The crashing of trees and the squealing and trumpeting as the elephants fed, quarreling over choice morsels, resulted in a din such as we had never before heard from elephants.

Our men kept innumerable fires going for fear that the elephants might take a notion to raid the plantain grove in which we were camped, and at daylight I was off for the day's hunt. The herd had drifted down to the forest side, forty minutes from camp; in fact many of them had entered the forest. For a couple of miles we traveled through a scene of devastation such as a cyclone leaves in its wake: 8-foot grass trampled flat except for here and there an "island" that had been spared; half of the scattering trees twisted off and stripped of bark, and of all branches and leaves.

We approached within a few hundred yards of the forest, where the grass was undisturbed except for trails showing how the elephants at daybreak had trekked through in small bands, single file. When about to cross a little wooded gulley, we thought it wise to stop and look over the situation. From the top of a mass of rocks we discovered a cow feeding only 20 yards away and others all about in the high grass between us and the timber (see page 783).

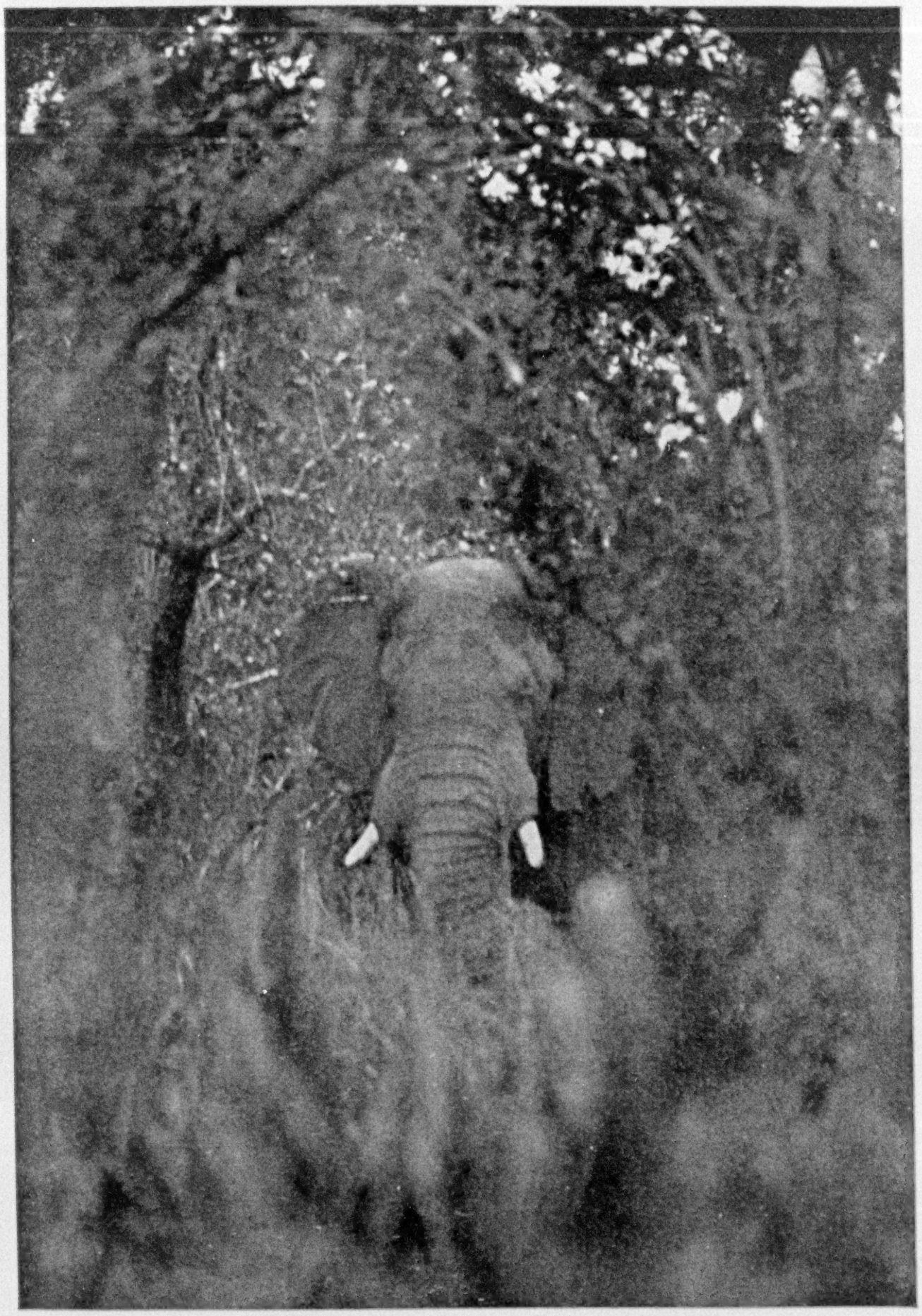
There was clear passage to a rocky elevation 100 yards to the left, for which we made, and while standing there, 75 feet above the level, I received an impression of Africa that must remain with me to the last.

There was not a breath of wind, and the forest, glistening in the morning sunlight, stretched away for miles to the east and to the west and up the slope to the north. Here and there in the high grass that intervened between our perch and the forest edge, 300 yards away, were scattered elephants singly and in groups feeding and loafing along, to be swallowed by the dark shadows of the dense forest side.

SCOUTS IN ACTION

From the gulley which I had started to cross a little time before there stalked 25 or 30 of the great beasts, their bodies shining with a fresh coating of mud and water from the pool where they had drunk and bathed. As is usual with big herds, they had broken up into small bands on entering the forest, and now, as the last of them disappeared into the cover of the trees, a fuller appreciation of the surroundings suddenly dawned upon me. From a mile or more in either direction there came a reverberating roar and crash as the great hordes of monsters ploughed their way through the tangles of vegetation, smashing trees as they quarreled, played, and fed, all regardless of forestry regulations.

Where the little stream at the bottom of the gulley entered the forest, troops of black and white Colobus monkeys were racing about the trees, swearing at the elephants. From the tree tops deeper in the forest two or three troops of chimpanzees yelled and shouted at one another or everything in general, baboons barked, and great hornbills did their best to drown all other noises with their discordant rasping chatter.



IN THE FORESTS OF UGANDA

Elephant hunting brings much that is fascinating. Never to be forgotten was that moment when, after hearing the scuffling of great feet among leaves, we came face to face with one of the great beasts in the dim recesses of the jungle. When leaving camp I had said to Mrs. Akeley, in jocular mood, that I would shoot an elephant at 11 o'clock. Remembering this as I came up with a loitering bull in the rear of a herd, I decided to take a photograph showing his small tusks, as an excuse for not shooting as promised. The photograph shows this young elephant, which was about the size of "Jumbo." Encouraged by the result, I continued photographing members of the herd for several hours.

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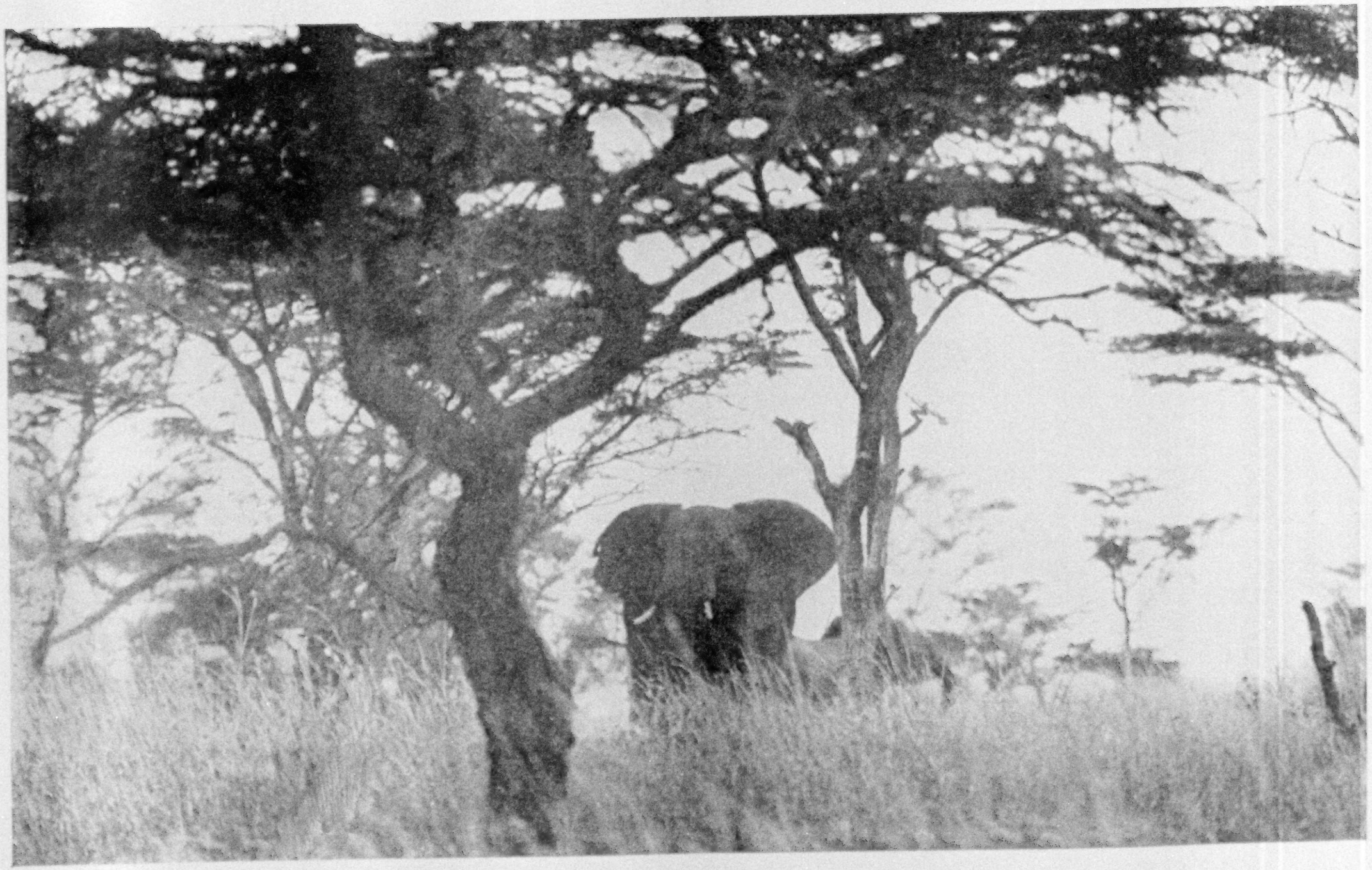
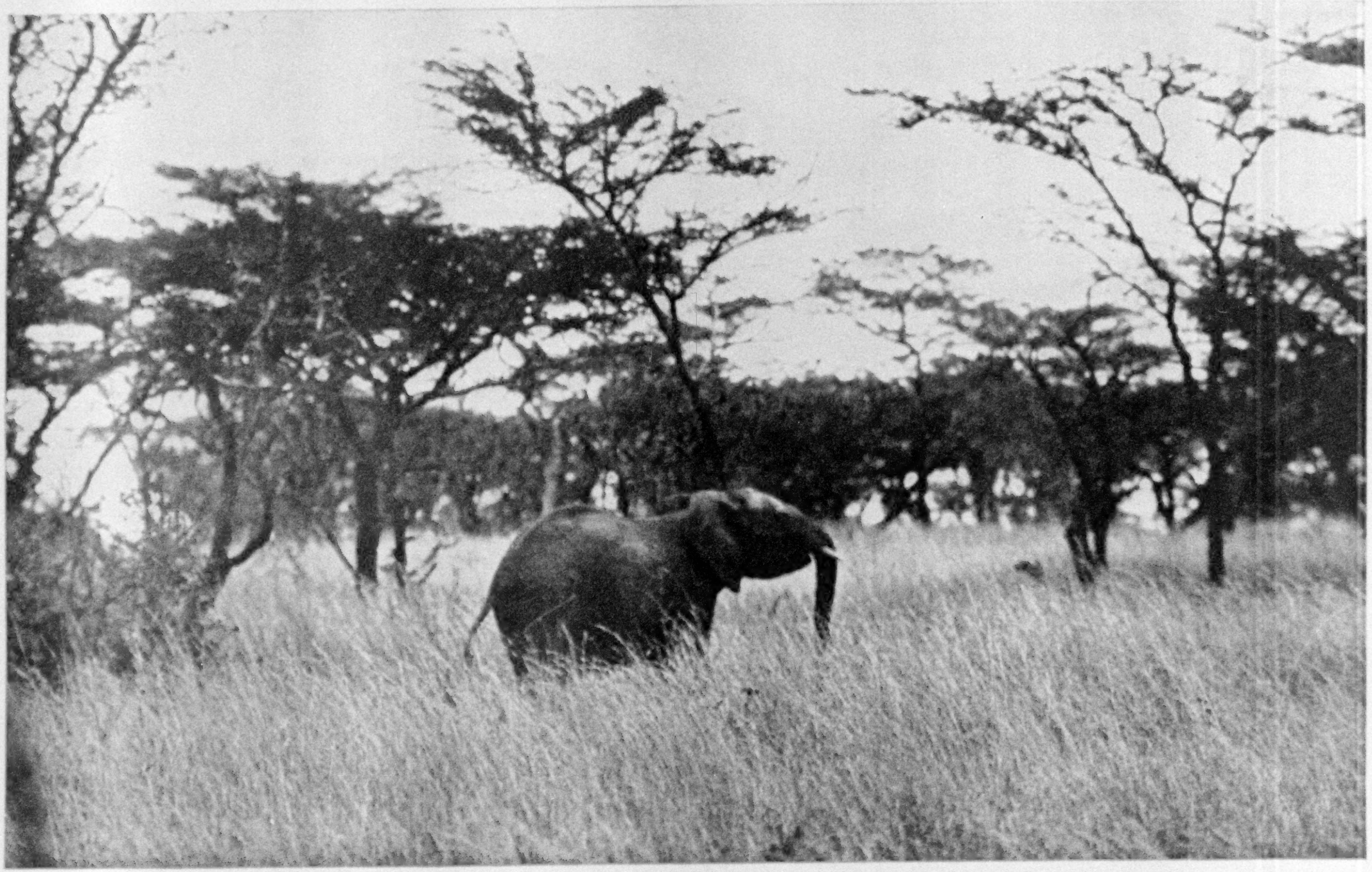


A CHARGING COW ELEPHANT

When approaching this cow from behind we made some slight noise, at which she wheeled and charged at once, paying the death penalty in consequence. The photograph was taken as she started and there was not time to change plates and get the second. The next cut shows the offspring of this cow, a youngster three or four years old and quite able to take care of himself.



A YOUNG ELEPHANT IN TYPICAL ELEPHANT COUNTRY

Offspring of the cow that charged; 3 or 4 years old and quite able to take care of himself. The youngster took some time in deciding whether or not to take the chance of following his mother's example, thus giving an opportunity of securing good photographs

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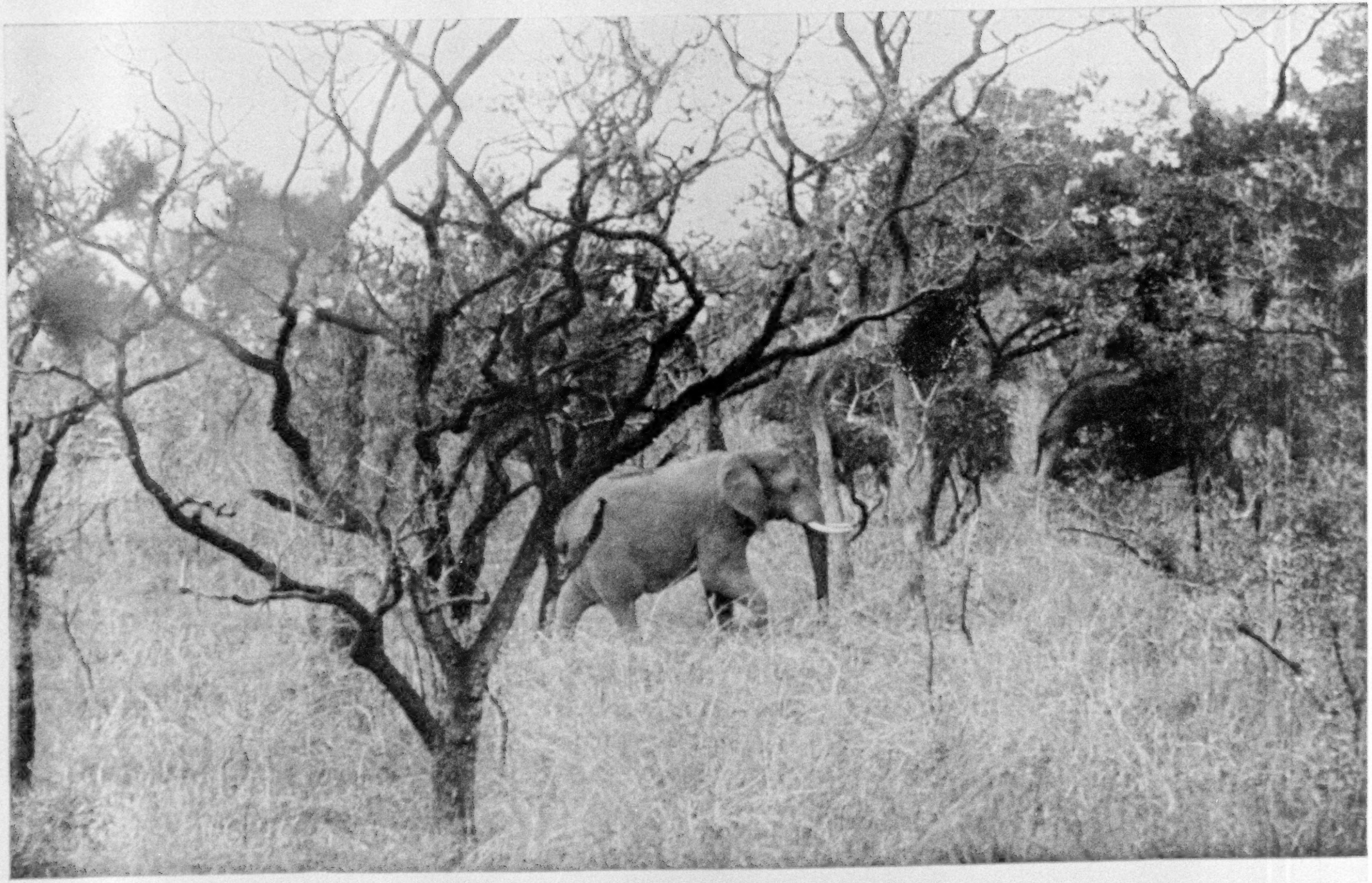


TREKKING THROUGH ELEPHANT COUNTRY

Elephant trails are easy to follow through grass, which shows plainly where the animals trekked in single file (see page 779)

Suddenly a cow elephant at the edge of the forest just in front of us uttered her peculiar shrill scream of warning. Not only the elephants, but all the other forest folk, paid heed and instantly were silent; a moment before the noise had been appalling; the silence now was even more so. Then there came a gentle rustling sound like that of leaves stirred by a breeze, increasing in volume until it sounded like a mighty windstorm in the trees.

I looked about to see whence it came. With my glasses I scoured the forest far and near, but not a visible leaf seemed to stir. Then I realized that the sound was made by elephants on the move, hastening away from danger—the scuffling of their feet among the dry leaves on the ground and the scraping of their sides against the equally dry leaves of the bushes. In a way this was even more impressive than the great din or the death-like silence preceding.

The old cow had caught a whiff of air tainted by man and all obeyed her warning. In a few moments the rustling subsided; the monkeys and birds returned to their normal state. The elephants had evidently settled down without going far; but only at rare intervals during the rest of the day did we hear the squeal of a chastised youngster or the breaking of a tree.

With my gun bearers I went down into the forest. Trails crisscrossed in all directions, so that it was impossible to follow a given trail any distance. A band of a dozen or so got our wind and passed us in confusion at close range, but the bush was so dense that I had but small glimpses of them. A mile into the forest brought us to an irregular clearing, 200 by 500 yards in extent, almost bisected by a "peninsula" of forest.

A WARLIKE MOTHER

At the base of this peninsula I nearly ran against a young bull, one of a considerable number, as I soon discovered. The whole herd began working toward the point of the peninsula and I ran along the outer edge to head them off. Just as the leader emerged from the point, they saw or winded us—shifty, uncertain breezes had sprung up—and they turned back. I ran into the timber to try for a better view of them. I soon found myself facing a cow who, solicitous for her very young calf, had wheeled about, all attention and menacing.

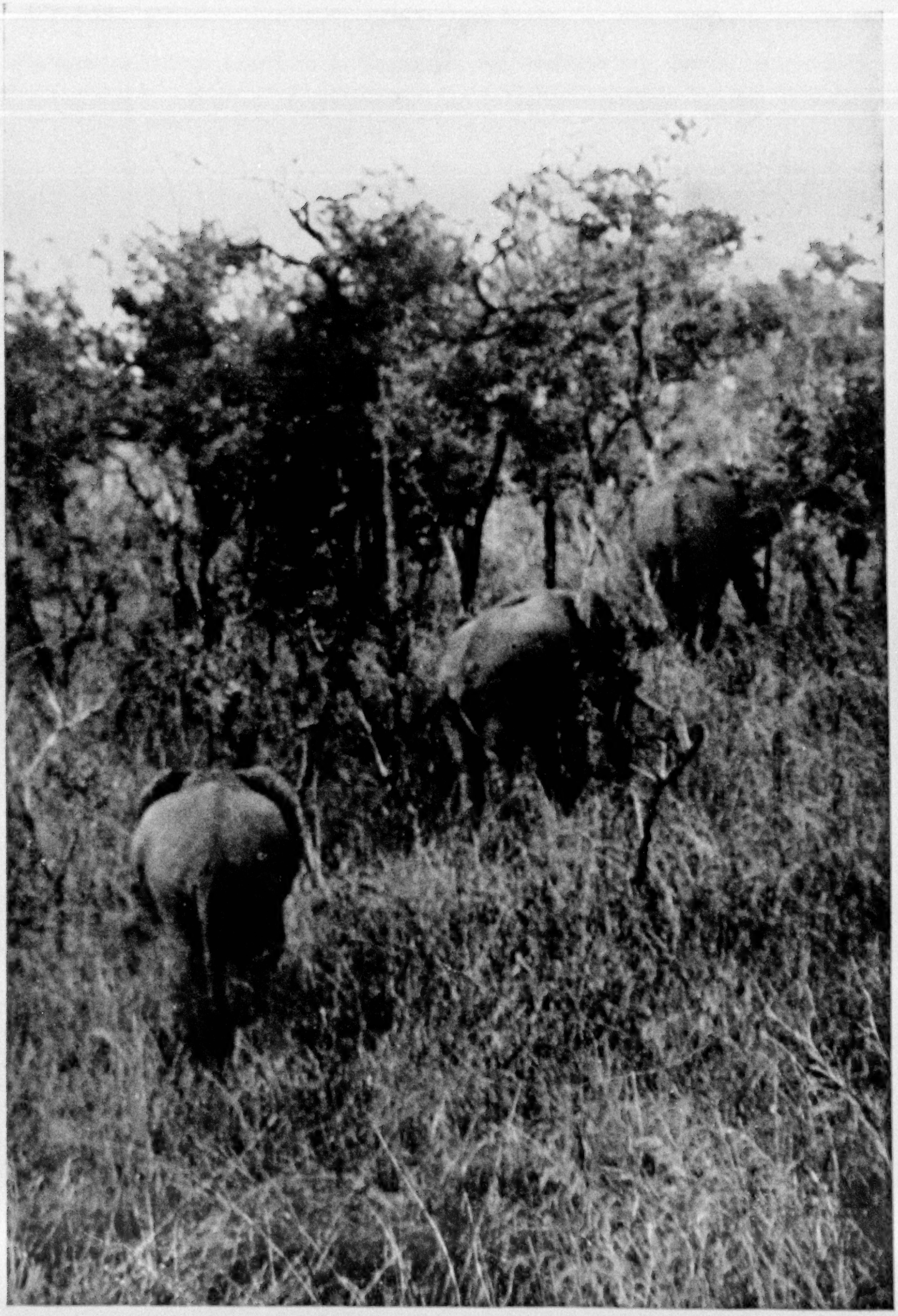
Fortunately, at the moment we were partially screened behind a clump of small trees, and as we remained motionless the cow's fears were soon allayed, and, turning, she gave the calf a boost with her trunk and followed the herd, which was moving off toward the clearing on the other side.

Hurrying out and around the point, I found the herd in the clearing, rounded up in close formation, conscious of the presence of an unseen enemy. There were about 25 elephants, mostly cows, and just as I was on the point of backing off to a safer distance, thinking there were no big bulls in the lot, a fine pair of tusks appeared at the near side. A clump of bushes offered cover for a near approach and I went in quickly to within 20 yards of him, and as his front leg was thrust forward offering a good opportunity for a heart shot, I fired both barrels of the double rifle in quick succession.

RENDERING FIRST AID

All was commotion as I seized my second rifle and, seeing that there was no direct charge, retreated some 50 yards to the top of an ant hill, from which I could see what was going on. I then witnessed a scene such as I had heard described and which I had been keen to verify. A number of cows were clustered about the bull, for he had fallen 30 yards from where he was shot, and with their tusks and trunks were doing their best to get him upon his feet; the remainder of the cows were doing patrol duty, rushing about in an increasing circle, searching for the source of trouble. That meant me, so I retired to a safe distance and waited for the atmosphere to clear.

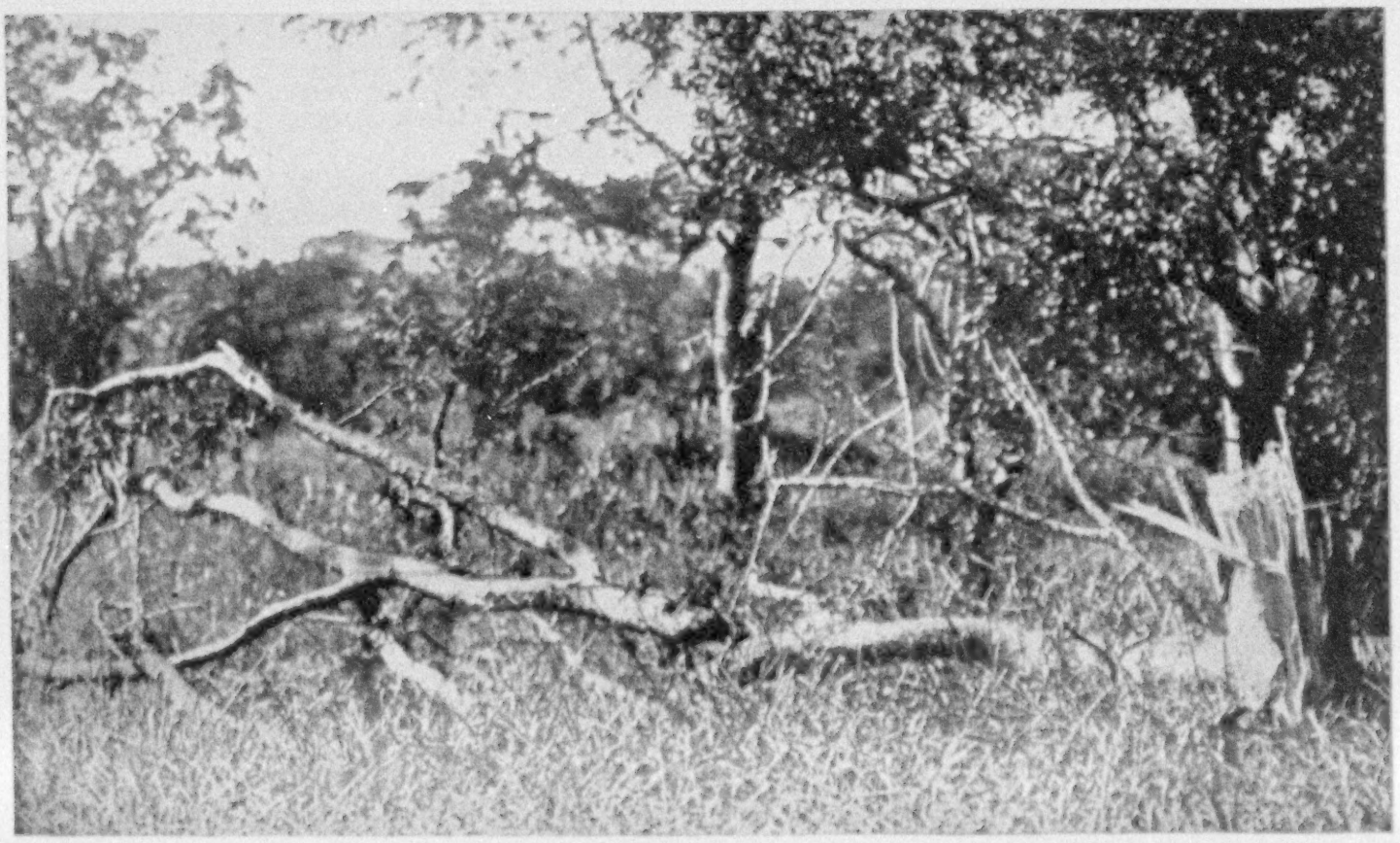
This bull stood 11 feet 4 inches high at the shoulders, and the tusks weighed 95 and 110 pounds respectively, while the circumference of the front foot around the sole was 67½ inches, the largest recorded, I believe (see photo, page 789).



PART OF A HERD OF SEVEN BULLS THAT WE TRACKED ALL DAY ONLY TO FIND THAT THERE WERE NO LARGE-SIZED TUSKERS AMONG THEM

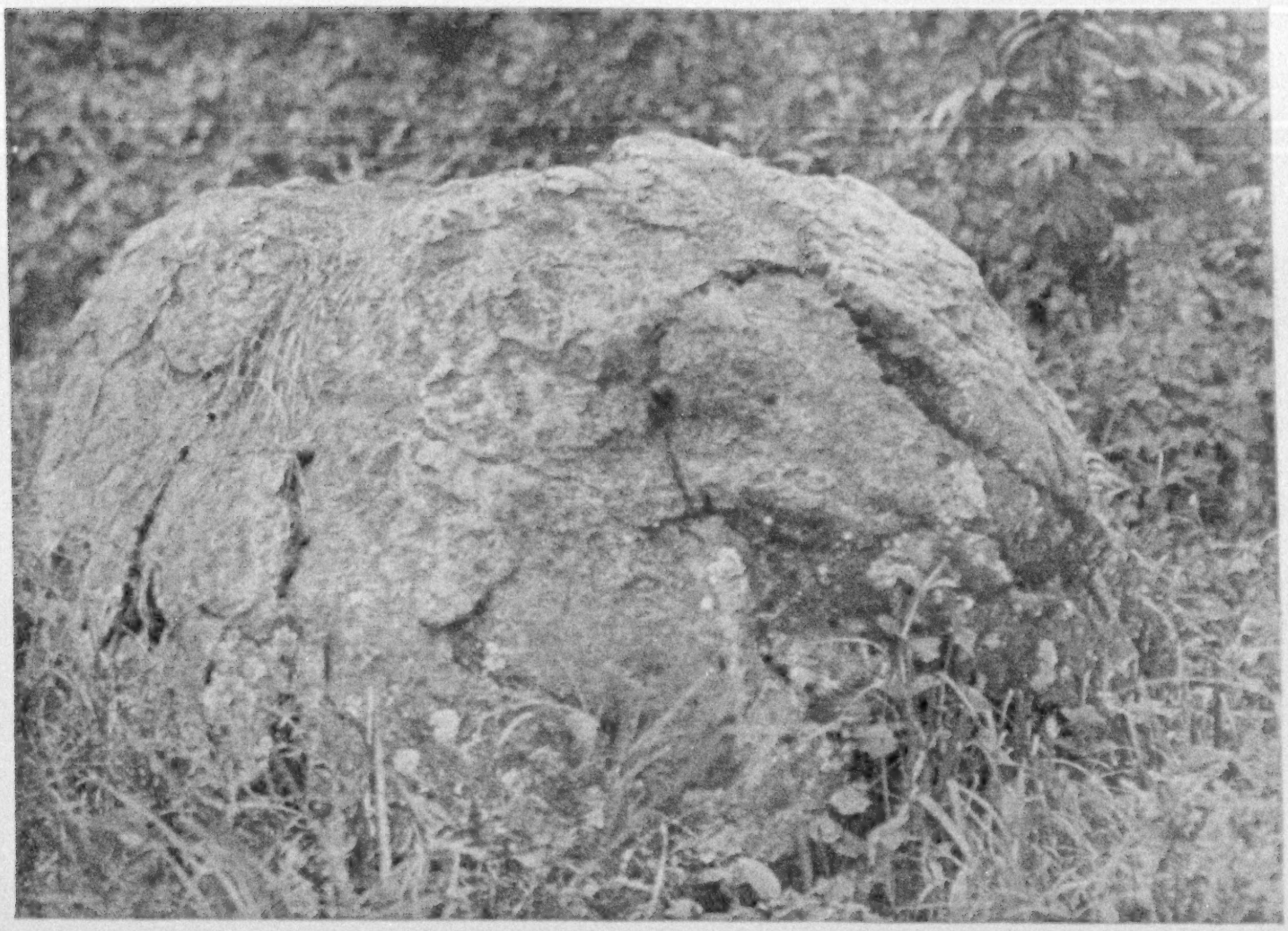
DEVASTATION BY ELEPHANTS

In this garden during the night previous, elephants had destroyed a large plantain grove and broken down fifty or more bark cloth trees averaging a foot in diameter. Elephants come in herds to villages deserted because of sleeping sickness. The damage is usually accomplished by herds containing no large ivory, and which consequently have been unmolested by hunters until they are contemptuous of man (see page 805).



A GREEN ACACIA TREE 15 INCHES IN DIAMETER BROKEN DOWN BY A SINGLE ELEPHANT, STRIPPED OF LEAVES AND SMALL BRANCHES

I have seen a small elephant break a 6-inch tree, not by pulling with trunk or ramming it, but with a side thrust of one tusk, using the trunk only to hold the tree from slipping along the tusk.



BOULDER POLISHED BY THE RUBBING OF GENERATIONS OF ELEPHANTS

The following day I went into the forest again and soon came up with a herd, but in cover so dense that an inspection could not be made. We worked with them for hours, and finally succeeded in driving them out into the open, but unfortunately the grass was high and I had not succeeded in gaining a point of vantage, when with angry grunts they doubled back to the forest.

As I turned to follow, my attention was called to a commotion in the bush at the edge of the forest some 400 yards to the left. Another herd was coming out into the grasslands, and from the top of an ant hill I saw them distinctly as they passed over a rise 50 yards away. There were 11 cows. I waited a few moments, thinking that, as often happens, a bull might follow in their wake. The cows had passed on to a distance of 300 or 400 yards, and I was about to leave the ant hill and return to camp when from the direction of the cows there came a low, ominous rumble like distant thunder. It was not very unlike the angry rumbling sounds we had so frequently heard when with elephants, but it was plain talk and meant trouble.

A hasty glance around convinced us that there was but one thing to do, to stand and meet the charge from the elevation where we were and from which we could see. If we tried to escape to one side or to the forest we could not see them over the high grass before they were upon us.

A LIVING TORNADO

The rumbling was repeated two or three times, increasing in volume, and was then followed by the wild shriek of one angry cow and immediately taken up by 10 others as they charged toward us. They came half way and stopped for a moment. They had lost the wind, but immediately caught it again, and roaring and screaming with redoubled energy came into view over a slight rise. It was a disconcerting spectacle. Their great ears at full spread, trunks thrashing wildly, a roaring, screaming mass, 40

FIGHTING BULLS IN A MAKE-BELIEVE FIGHT

There were elephants on three sides of me when this photograph was taken, which explains the inaccurate focusing of the camera

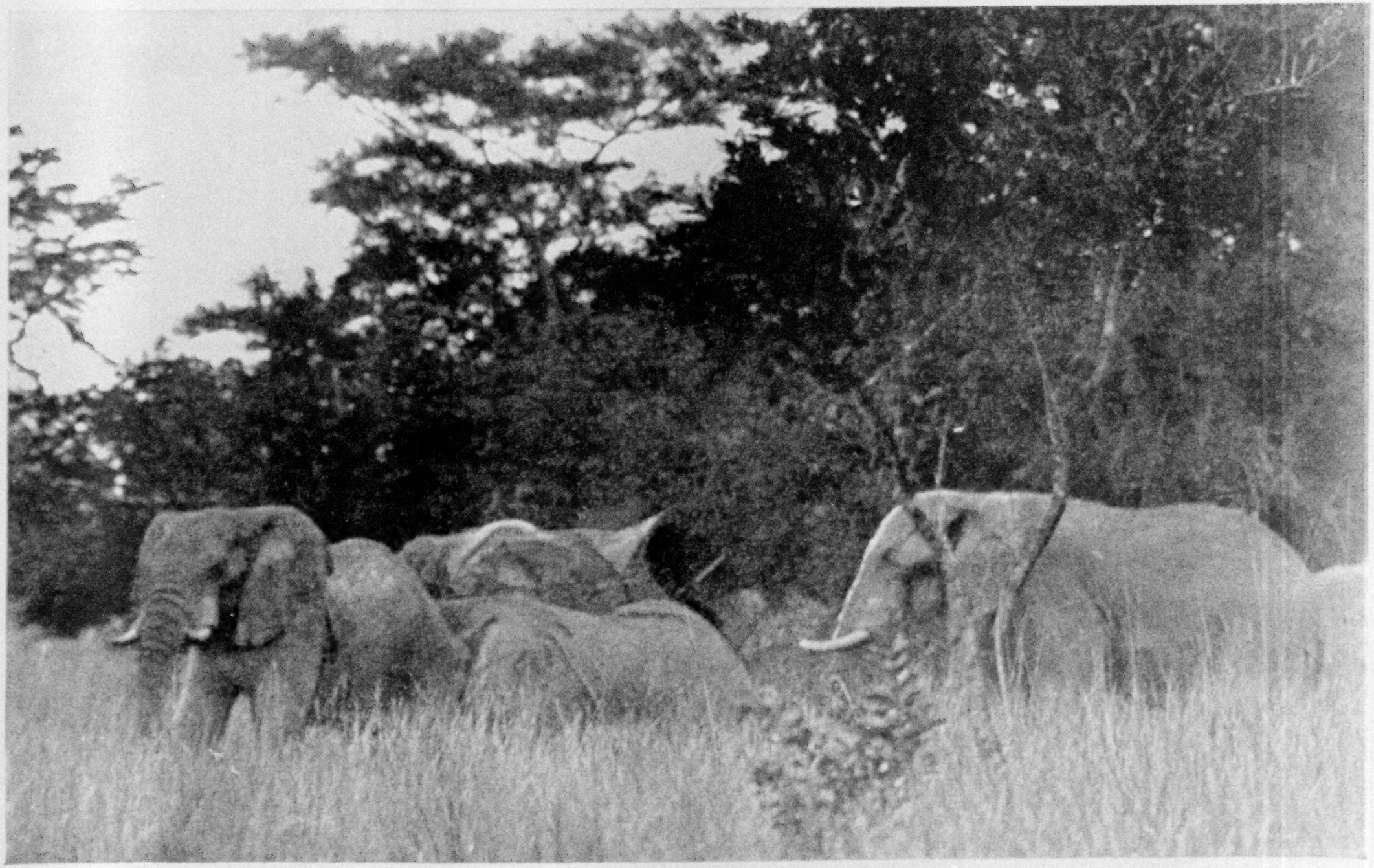
XUM

A LARGE BULL: ONE OF THE HERD OF 700 ELEPHANTS

Height at shoulders, 11 feet 4 inches; circumference of front feet (sole), 77 inches and 77½ inches, the largest recorded. Right tusk (showing in picture) weighed 110 pounds; the left weighed 95 pounds, the lighter weight being due to slower growth because of an injury at the base of the tusk in early life, resulting also in a knotty rib along the entire length of the upper side of tusk. The oldest bulls are those which have long been protected in large herds of aggressive cows and young animals. A number of cows did their best with trunks and tusks to get this fallen companion to his feet (see page 784).

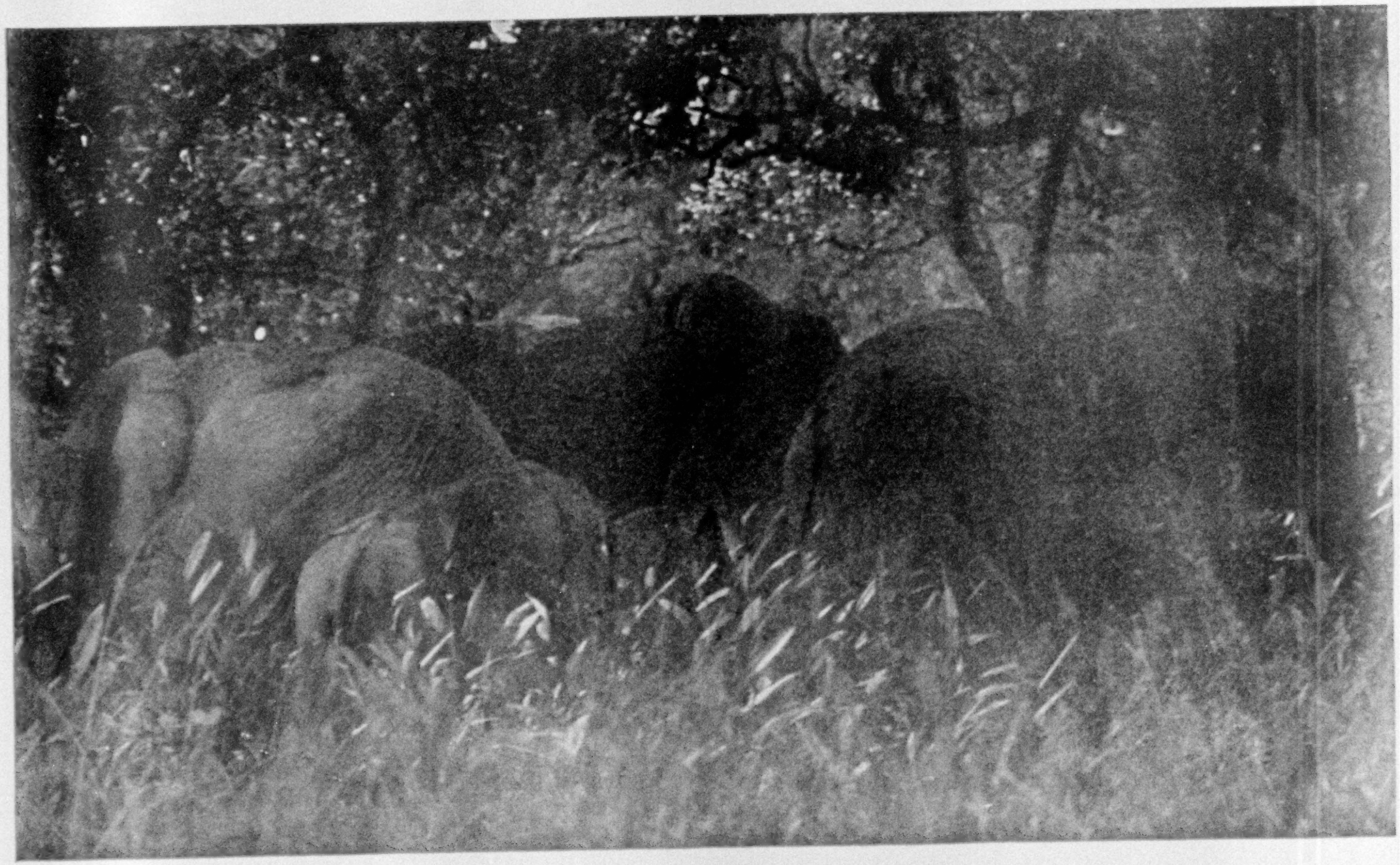
THE PLATEAU TO THE EAST OF MOUNT ELGON

Four herds of elephants are in sight, consisting of cows and young animals of inferior grade. Mr. Akeley inspected more than one hundred elephants in the Mount Elgon district without discovering a single large specimen, all the valuable elephants having been killed off by ivory hunters; the herds remaining, having been unmolested for some years, are unusually vicious in temper (see page 795).



A SMALL HERD WITH ONE YOUNG BULL FACING READY TO CHARGE

"I ran around a clump of bush to head off this band of young bulls, and found myself closer to them than I expected. One of them saw me and I was expecting trouble when the camera clicked, but they bolted and I got a second picture as they turned."



ELEPHANT COWS AND CALVES RESTING IN THE FOREST

They are quietly enjoying the midday siesta. A gust of wind blowing toward them from our direction would be certain to result in a charge. Note the calves crowding their mothers

A BABY ELEPHANT'S MARBLE

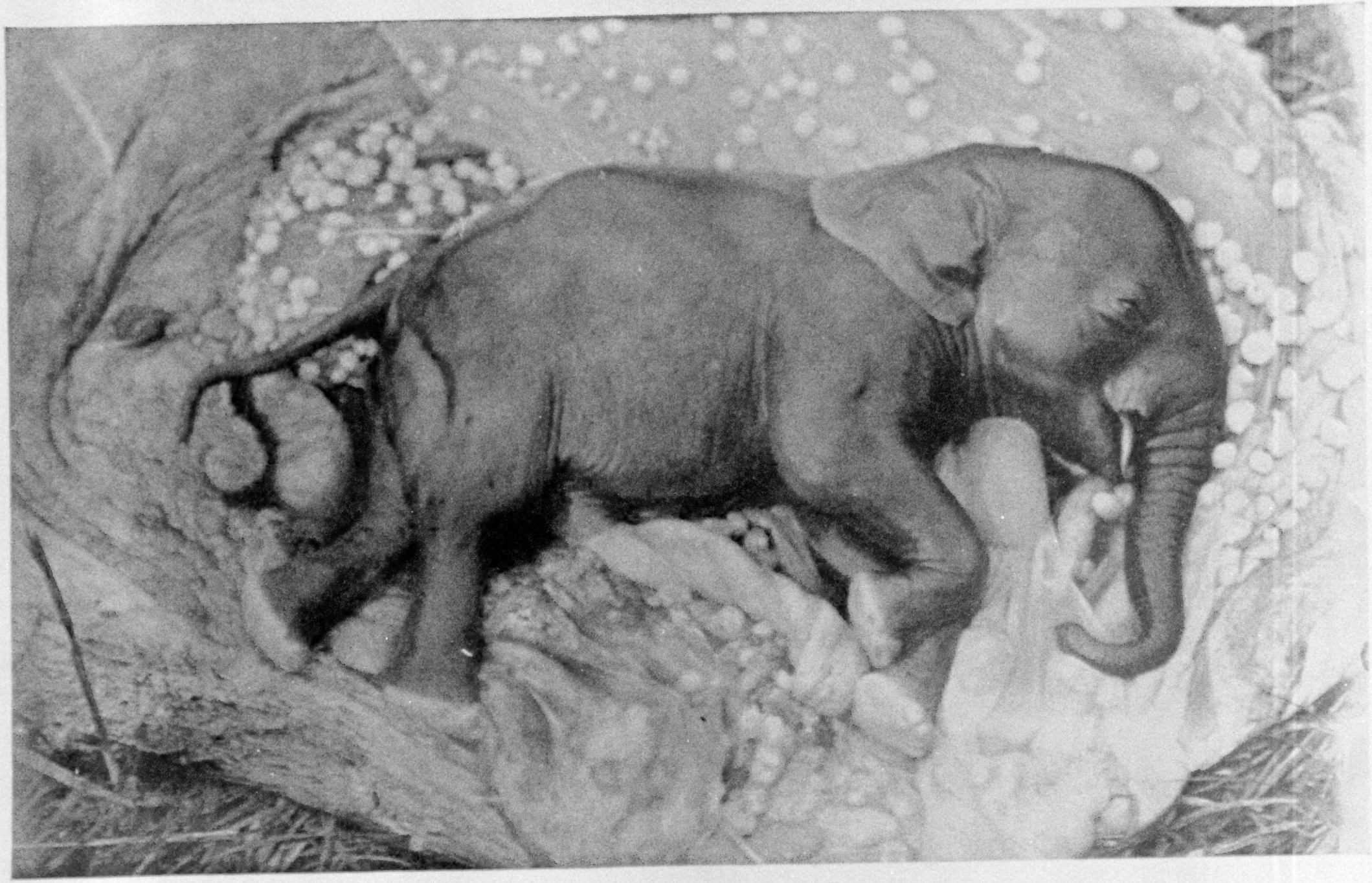
A fragment of a termite hill that the elephants had broken off and rolled about on muddy ground until it had become a nearly symmetrical sphere. They had evidently rolled it to this point from a considerable distance, as it was of black earth, while the ground where photographed was yellow. Baby elephants, like most young animals, are fond of a frolic with one another and sometimes at the expense of other animals. One day while inspecting a large herd of elephants that were feeding on the opposite side of a ravine, we met a herd of buffalo in the high grass on our side, and when we succeeded in frightening them off they stampeded across to where the elephants were. Three young elephants left the herd and gave chase, squealing and trumpeting as they charged this way and that, scattering the buffalo, but not driving them away. The buffalo showed no great fear, just keeping out of reach; sometimes a cow whose calf was being hard pressed would face about and make a bluff at standing her ground, but always turned tail when the elephants got too close. As a rule elephants pay slight attention to other animals. Mr. Tarlton has seen a herd of cow elephants beat a lioness out of high grass and chase it into forest cover. This suggests the possibility of lions preying on young elephants, being recognized therefore as an enemy.

tons of frantic female elephant vengeance. I remember that I felt homesick.

Were they to continue in a straight course they would pass at 40 yards; then a dash on our part to one side and we could lose them and be safe. When they were nearly opposite us, however, they either saw or winded us afresh and wheeled straight in, with a burst of shrieks. A shot from the big cordite rifle stopped the leader, but, encouraged by the others, she came on, only to be knocked down by the second shot. The others crowded about her, sniffed and—bolted. The old cow slowly regained her feet and staggered away, while we in deep gratitude returned to camp.

HUNTING FOR UNUSUAL SPECIMENS

It was in August, 1909, that we left New York, commissioned by the American Museum of Natural History to secure specimens for a group of African elephants. We began serious work on the Uasin Gishu Plateau, knowing that there we should be able to secure the smaller specimens, cow and young elephants, and we had reason to hope that a large bull might be found on the plateau



ELEPHANT EMBRYO

Height at shoulders, 10 inches; estimated age, 8 months; that is, one-third of the period of gestation. Except for the slight oversize of head, the proportions are those of an adult elephant.

A MATERNITY BED WHERE A YOUNG ELEPHANT WAS BORN AND CARED FOR DURING THE FIRST WEEK OR TEN DAYS OF ITS LIFE (SEE PAGE 798)

This was found by the expedition while traveling by compass on Mount Kenia, well away from all trails

or in the forests of Mount Elgon, for in former days great numbers had inhabited the rich feeding grounds of the Elgon forest, as evidenced by the old pits (traps), scarred trees, and decaying bones. We inspected more than 100 elephants, however, without finding a trace of a single large specimen.

We journeyed to the summit of Mount Elgon from the south and down to the east without finding the least recent trace of elephants until we had returned to the bush country of the plateau. Then we proceeded to Uganda, secured porters at Entebbe, marched along the Hoima Road to the Kafu River, down the Kafu to where the old Masinde-Kampala Road crosses it, then to Masinde, seeing no elephants during the two weeks' journey (see page 790).

We then devoted a month to hunting in the region of the Victoria Nile between Masinde and Foweira. This is a region of big elephants, where many splendid tuskers have been taken in the past, but really good ones are now very rare. On this occasion we shot two bulls, enormous in size, but with tusks weighing only from 75 to 80 pounds each.

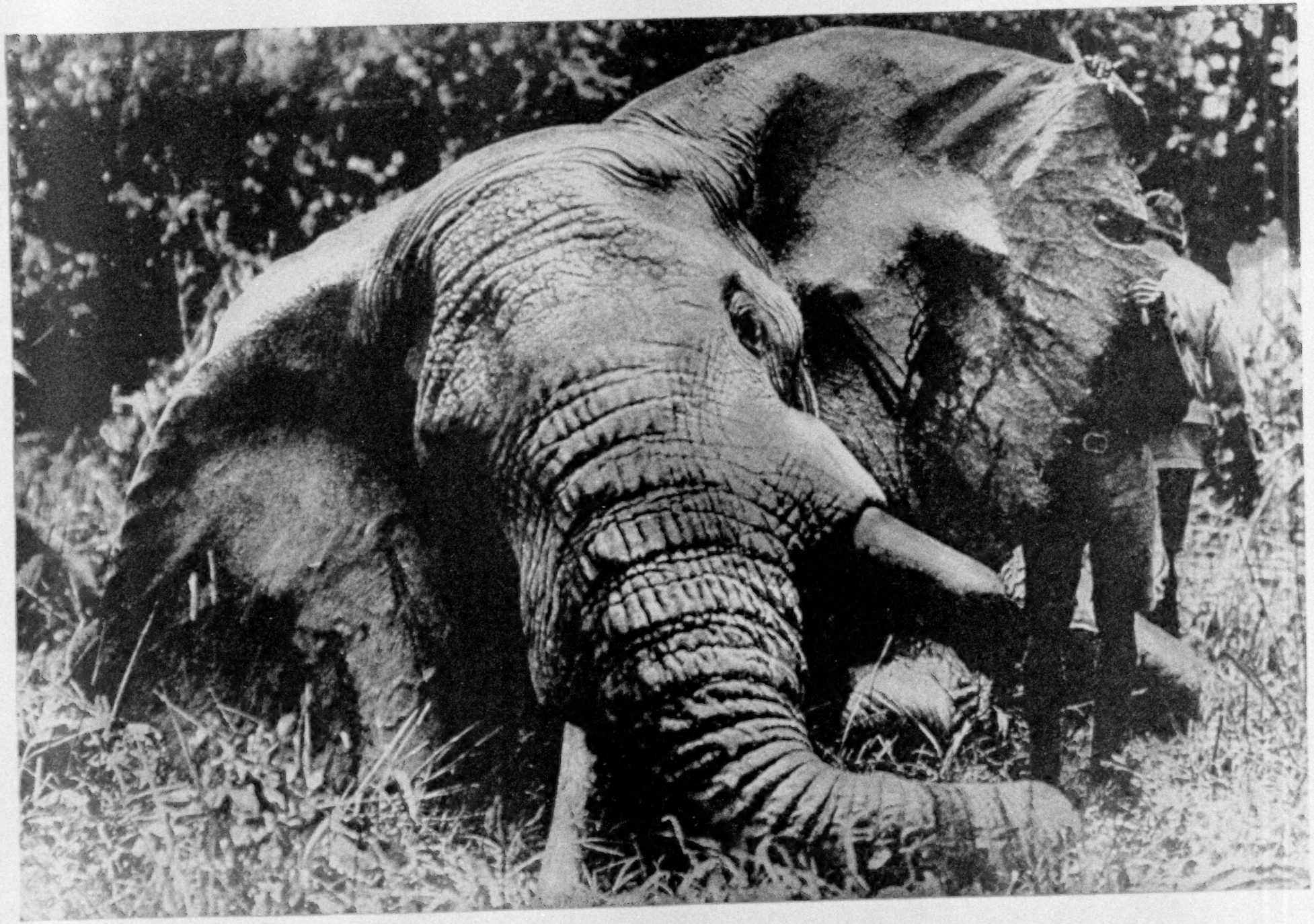
MOUNTAIN-CLIMBING ELEPHANTS

About the middle of April, as I was suffering from physical disabilities that made the preparation of an elephant skin impossible, we decided to return to the Uasin Gishu Plateau, where in the more healthful highlands I might hope for recovery. Though the rains were on at this time, we found no elephants on the plateau, so we devoted 20 days to lion hunting with a party of Nandi warriors for the purpose of making motion-picture records of the spectacular sport of lion spearing. About the middle of May we trekked across country to Mount Ke-

AN OPEN VISTA IN THE BAMBOO JUNGLE OF MOUNT KENIA

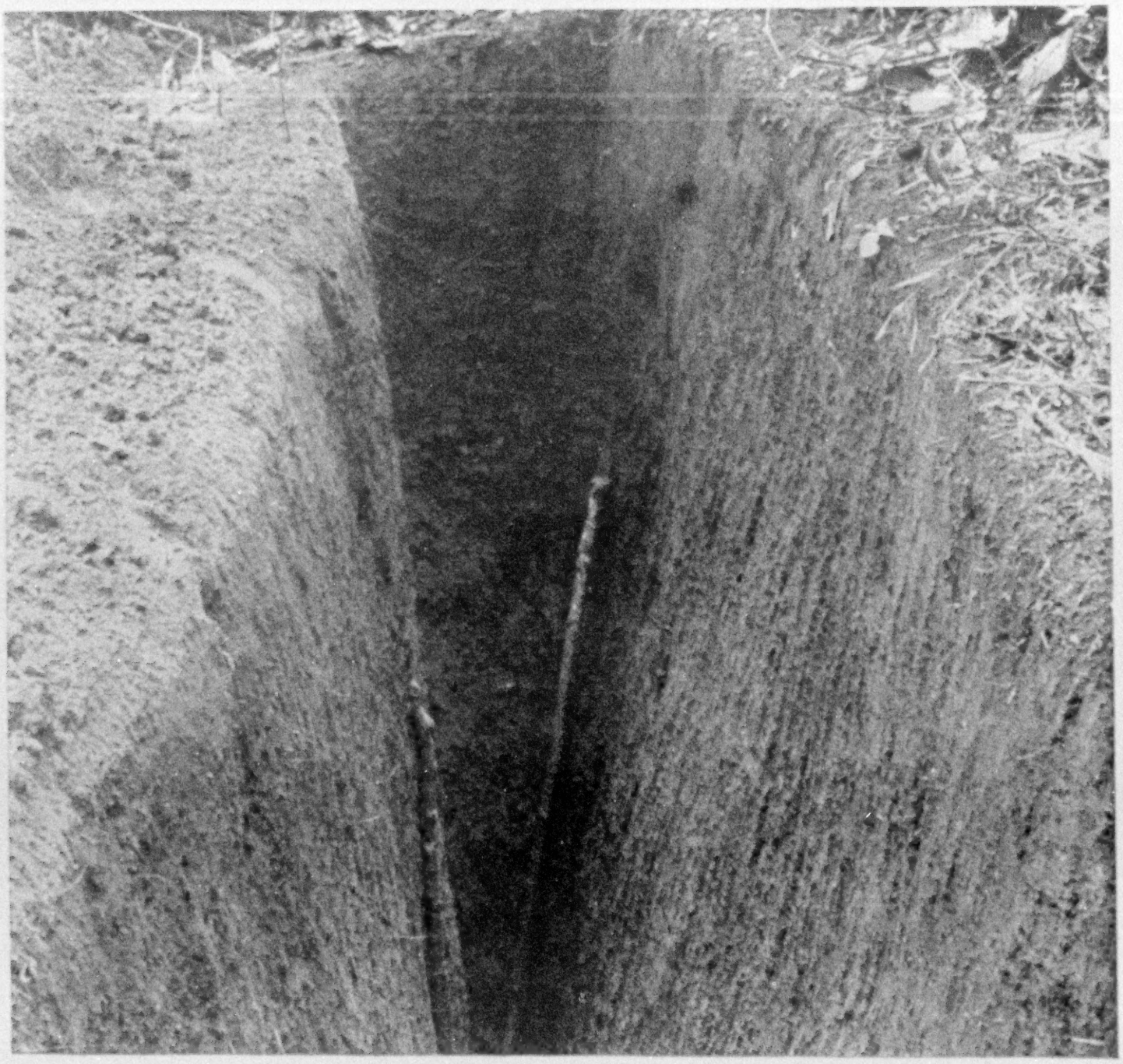
The cows and calves spend much of their time in the bamboos feeding on the succulent shoots of young bamboo

XUM



THE HUGE EARS OF A BULL ELEPHANT

One of a herd of 8 or 10 bulls. He was first knocked down by a well-placed bullet from Mrs. Akeley's rifle, but he regained his feet, and six bullets failed to stop him as he made off. When we came up with him a half-hour later he got our wind and charged ferociously. Our shots stopped him, but we fired at an angle that necessitated piercing great masses of bone to reach the brain. He charged the third time before a bullet found its way to the brain, just as he had nearly caught one of our boys. An extremely heavy, thick-set bull with short, thick tusks of 80 pounds each. His ears were extremely large, 6 feet 5 inches in depth.



A FRESHLY DUG ELEPHANT PIT

The top will be covered with cross sticks and concealed by earth loosely thrown over the sticks. The unwary elephant crashes through this cover, its great feet are wedged in at the bottom of the pit and it suffers a lingering death. An elephant pit is usually 9 feet deep, is large at the top (3 to 4 feet wide and 10 to 12 feet long), but tapers to a width of only 6 to 12 inches at the bottom. Pits are often made in groups of three, one in the trail and one a few yards at either side.

nia for the purpose of making studies for the setting of the elephant group.

The forests of the southern slopes of Mount Kenia are inhabited by forest elephants, who seldom if ever leave them except to make short night excursions into the gardens of the Wakikuyu natives. Wishing to learn something definite in regard to the limits of their range on the mountain, we made the ascent from the south through the timber and bamboo belts onto the snow fields at the base of the pinnacle. We found that the elephants regularly work up to timberline (12,000 feet), and we found comparatively fresh tracks in the sphagnum marshes at 14,500 or more feet.

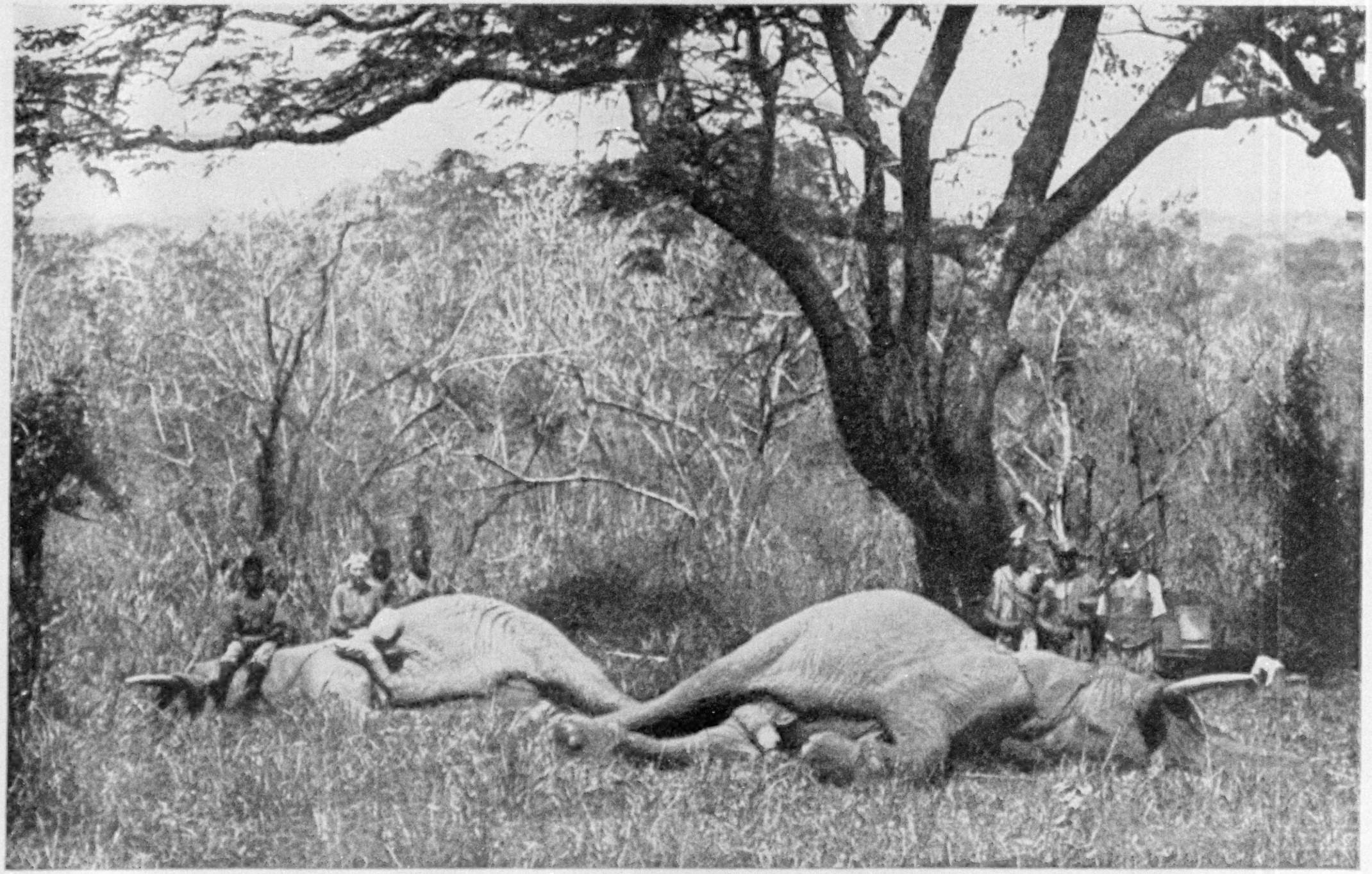
THE CRIB OF A BABY ELEPHANT

It was while on this excursion we found the "maternity bed" of an elephant. Under the protection of a great mass of aërial roots and the foliage of a great tree on the point of a densely for-

XUM

A COVERED ELEPHANT PIT

The pit has been completed only a few weeks, yet is effectively concealed even to the observing eye by a new growth of vegetation. The pit is a hidden menace to the hunter as well as the elephants. Fortunately they are not usually staked, and a fall into one usually results in nothing more serious than a good shake up. With the elephants it is different. Their great feet wedge in at the bottom of the pit; they become helpless and suffer a lingering death.



NOT A "RIGHT AND LEFT," BUT A "RIGHT AND WRONG"

We had followed a herd of a dozen elephants from morning till midday, when we came up with them as they were enjoying their siesta. There were several young bulls, any one of which would meet our requirements. One was chosen and we, Mrs. Akeley and I, agreed to shoot together to make certain of dropping him where he stood, in the shade of the tree, that we might be protected from the sun while preparing the skin; at the signal we fired and two elephants fell in their tracks.

A PIT-DIGGER'S SHELTER

The killing of elephants by natives is prohibited; nevertheless the Wandorobo of Kenia were never more active in digging pits than when we were there. When following native guides one does not often run across new pits; it is when traveling by compass, independent of guides, that one is most likely to disturb the trappers at their work. During a three months' stay on Kenia, in 1910, two elephants were killed in pits within a few miles of our camp. A pit may be many years old before an elephant is caught in it, and we were curious to know how the few hunters could watch the hundreds of pits scattered about a large area as they are. The method is simple and entails but little fruitless labor on the part of the natives. A pitted elephant may live some days before death comes to its relief, and then a signal is soon wafted down wind to which the hyenas and leopards promptly respond, the hyenas howling as they go in search of the feast, and the Wandorobo follow the howls and tracks of the other carrion feeders. The flesh of the elephant is thoroughly ripened by the time the natives reach it.

ested ridge, accessible from only one direction, there was a deeply trodden bed of dry earth, where the baby elephant had been born and had spent the first week or ten days of its life, while the mother watched over it or fed on the abundant vegetation near at hand. Later we found a second bed precisely similar as to situation. These beds were well off the lines of elephant travel (see picture, page 795).

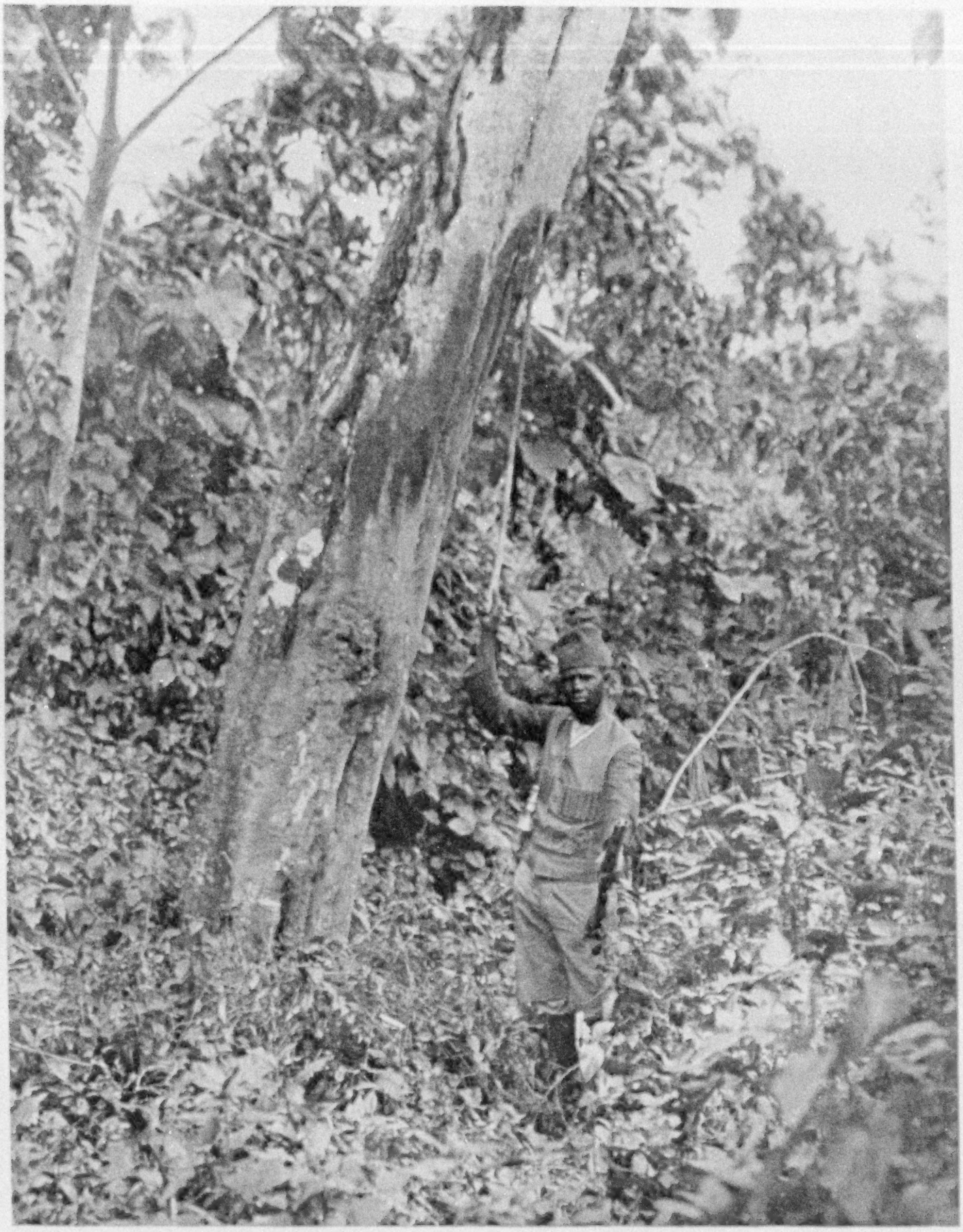
Upon returning from the summit of Kenia to the native gardens at the edge of the forest, I went back again to the bamboos to make photographic studies for the background and gather materials for accessories for the group. While thus engaged I met a bull elephant, which left me much the worse for the experience and necessitated my return to the base camp on a stretcher. This event postponed work for several months, and

WHEN AN ELEPHANT IS KILLED THE NATIVES CONGREGATE IN GREAT NUMBERS, GOING INTO CAMP ABOUT THE KILL, WHERE THEY SMOKE-CURE THE FLESH

Not a bit is allowed to go to waste. Note the pieces of flesh hanging in the foreground

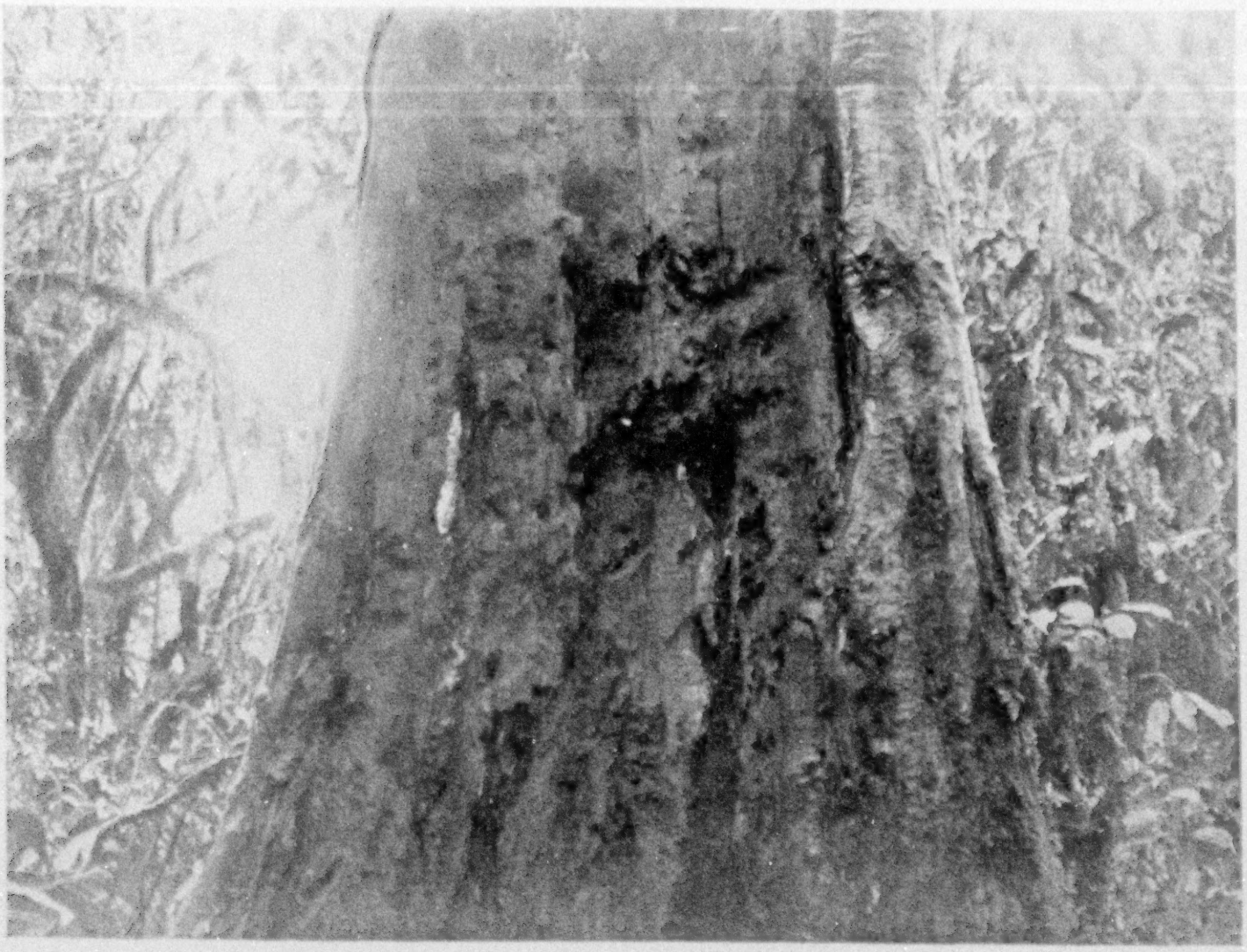
XUM

THERE ARE FEW TREES IN THE ELEPHANT COUNTRY THAT DO NOT SHOW THE SCARS OF WOUNDS FROM ELEPHANT TUSKS, AND THOSE BESIDE THE TRAILS ARE KEPT WELL POLISHED BY THE RUBBING OF PASSING HERDS



GUN-BEARER MARKING ELEPHANT RUBBING ON THE TREE

This man, a Swahili, was gun-bearer for Mr. Arthur Newman at the time he was nearly killed by a cow elephant on Kenia. One lung was punctured by the elephant's tusk, and the gun-bearer is reported to have killed the elephant, saving Mr. Newman's life. When a similar accident happened to me this gun-bearer ran to safety.



A TREE HALF DECAYED BECAUSE OF TUSK WOUNDS THAT NOW SUPPLIES THE ELEPHANTS WITH DRY PUNKY WOOD WITH WHICH TO DUST THEMSELVES

it was not until January, 1911, that we resumed active work in the field. From then until the first of June we worked in Unyoro, from the Victoria Nile on the east and north to Lake Albert on the west northward of Masinde.

This district has now been closed because of sleeping sickness, and thus becomes an elephant reserve. During the time we were there we saw much of the results of this awful disease, whole villages in which not a living being was to be found, those who had escaped alive having abandoned all household utensils and stored food, together with the huts and gardens, to the mercy of the elephants, who had come in great herds, destroyed the plantain groves and bark-cloth trees, completing the work of devastation.

The elephants do not always by any means wait for the natives to go. We saw many cases where they had raided a garden at night and completely destroyed all crops, and in some instances, when angered by the natives' attempts to drive them away, had destroyed the huts also.

THE DESTRUCTIVENESS OF A HERD

The amount of damage that a herd of 500 elephants can do to forests and native cultivation is enormous. In following a herd of 250 we were led through a garden, where the night previous elephants had destroyed a large plantain grove and broken down 50 or more bark-cloth trees, averaging a foot in diameter. This was a herd from which all good bulls had been killed and the remainder, enjoying immunity from sportsmen and ivory hunters, had become contemptuous of man (see page 786).

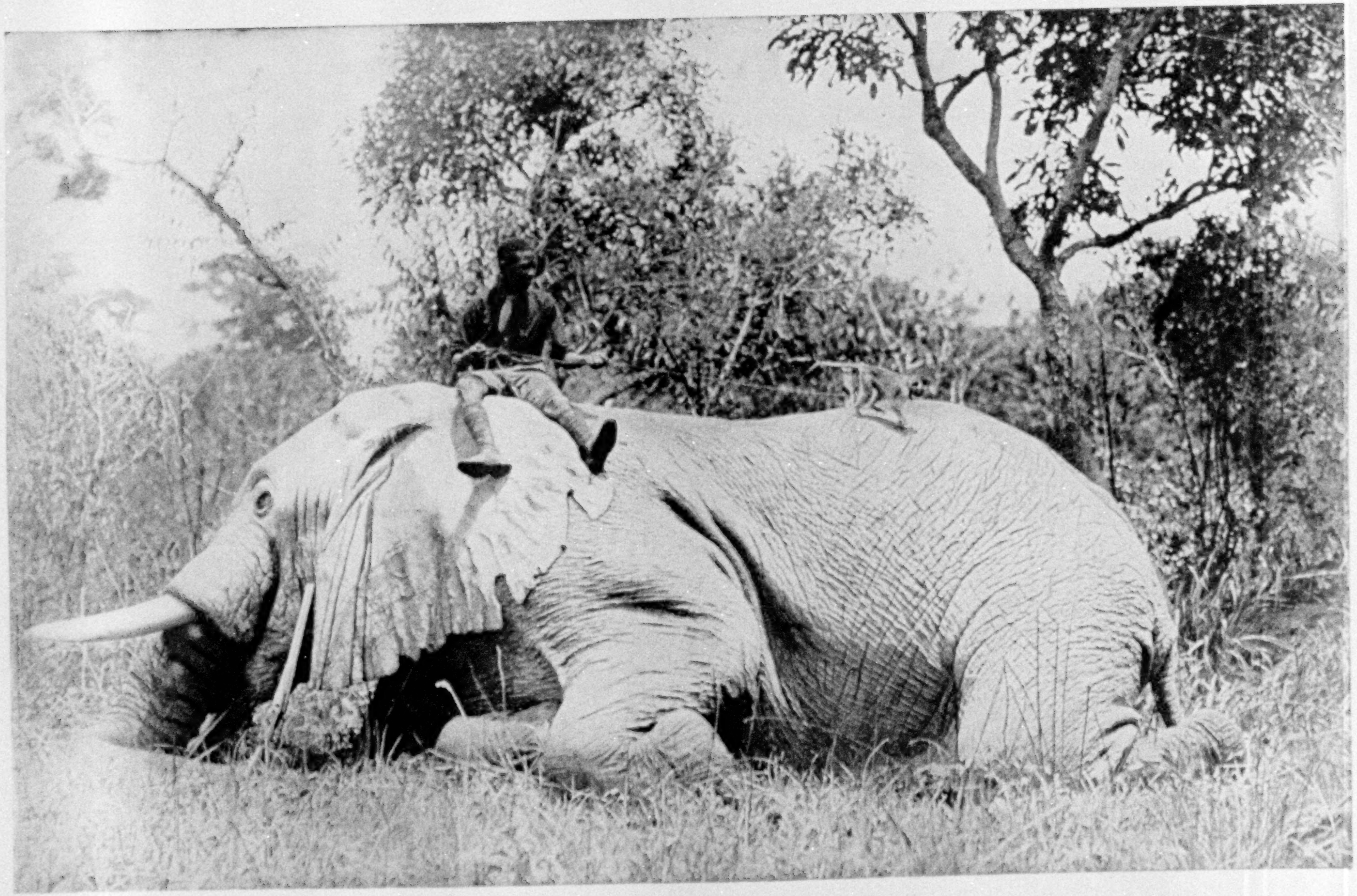
When we approached the herd and they became aware of our presence, they surged down upon us, keeping us at a distance, and not until I climbed a tree in advance of them did I get a chance to look them over as they approached and

MOSS-COVERED ELEPHANT SKULL IN THE BAMBOOS NEAR TIMBER LINE ON MT. KENIA

passed. The average value of ivory in this herd would not have exceeded $20 per head, not enough to cover the damage done by them in one year.

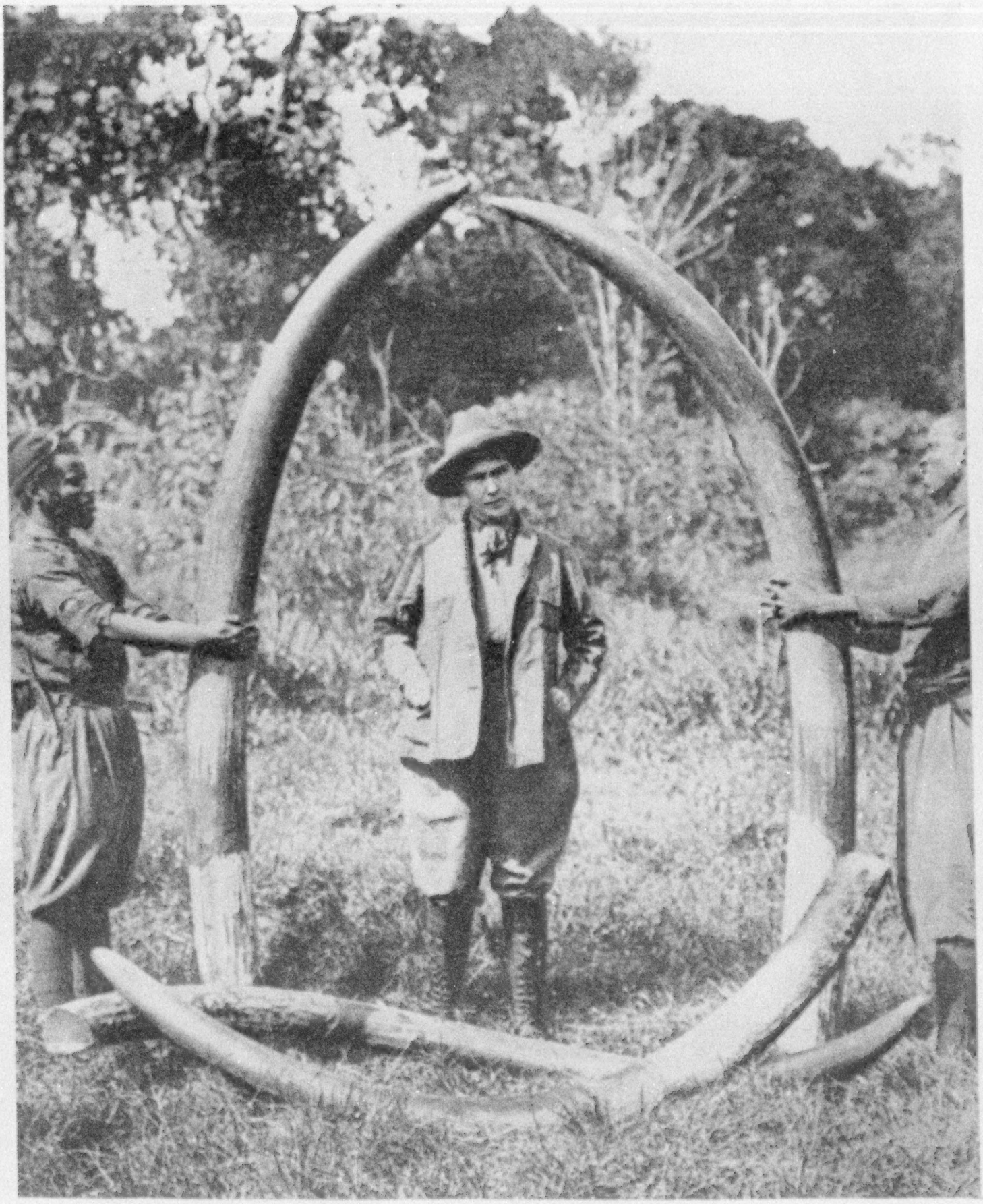
Coming south from the neighborhood of Murchison Falls, we were resting at the summit of the pass over Poduro Hills, when we detected a herd of about 100 elephants at rest some 2 miles to the south. As we watched them they began moving in our direction and ultimately reached the base of the hills, where we met them. In the meantime a second herd of more than 100 appeared, traveling rapidly to the north, passing within easy inspection range of our outlook. During the time we were engaged in watching these elephants the middle ground was occupied by two herds of buffaloes, and as we went down to look the elephants over at the foot of the hills we jumped the third herd of buffaloes in

XUM



THE BIG FELLOW WHO NEARLY FINISHED "J. T. JUNIOR"

"At the third desperate charge of the huge beast, and just as he was almost upon the tent boy, who was carrying J. T. Junior, a lucky shot brought him down. It took some time for the monkey to screw up courage to go on an exploring expedition over the body of his late enemy." The monkey, named "J. T. Junior," was captured on the Tana River in the first month of the expedition's travels and remained a member of the party throughout the two years—often the most helpful member in the good cheer he furnished. In the climb of Mount Kenia he was stricken with mountain sickness at 15,000 feet elevation and had to be sent back.



MRS. AKELEY WITH THE TUSKS OF HER TWO MOUNT KENIA ELEPHANTS
The combined weight of the four tusks was over 400 pounds, a record

XUM

IVORY CARAVAN

A caravan with 97 tusks from the Haut Fturi. The largest weighs 106 pounds and is 9 feet long. Trade in the Congo is now in the hands of several nationalities

the bamboos. There were over three hundred in all.

It is generally understood that large bull elephants are more frequently to be found apart from the herds, but our experience does not bear this out. Three bulls that we have shot, having tusks each weighing 100 pounds or over, have been herd bulls. In Uganda we often found bulls unaccompanied by cows, singly and in small herds numbering up to 15 individuals, but it was not among these that we found the largest tusks. We have found the large old bulls enjoying the society and protection of large herds of cows and young animals (see page 789).

A GUARD OF HONOR

One splendid old bull well known in Uganda, who has been seen by many hunters, is so well protected by a large herd of most aggressive cows, who charge at the slightest intimation of danger, that he still survives. These old bulls are very rare, for when a bull has developed tusks of 50 pounds, which is at quite an early age, perhaps 25 years, he becomes the target of every hunter, native or white, who sets eyes upon him; thus it is only the more crafty or timid individuals that, seeking the protection of large herds or clinging to the more inaccessible regions, such as dense forests, manage to survive to a ripe old age and develop a full growth of ivory.

The best bull at present in our collection for the group is a young adult standing 11 feet 3 inches at the shoulders with tusks of 100 and 102 pounds respectively. These are young ivory, and there can be no doubt that were this elephant to have lived 50 years longer they would have attained a weight of 200 pounds each. Such tusks are not abnormal; they are simply the tusks of a good, healthy bull who has been intelligent and lucky enough to keep his life until his ivory was full grown.

It would seem worth while that the world's permanent record of elephant life should contain a specimen that illustrates the fullest development of the African species, the finest living representative of this race of animals. Such an elephant can be secured now, but it will soon be too late, for the remaining monster specimens will be killed for their ivory.

ZANZIBAR

By Mrs. Harris R. Childs (Eleanor Stuart)

HUNDREDS of tourists and government employees, on the manifold errands of empire, see the town of Zanzibar without knowing much of it, or ever exploring beyond the German or English tennis clubs. But this is less remarkable than the fact that merchants, priests, secular missionaries, military and diplomatic whatnot, Indians, Arabs, Parsis, and Europeans (as inconspicuous artisans or petty traders) actually live in the town year in and year out without so much as walking half a mile beyond the terminus of the little American railway at Bu-bu-bu, a village a few miles from the town itself. The precedent for this neglect—and the social fabric of Zanzibar is dependent on precedent—is undoubtedly the indifference of the early explorers, who fitted out caravans in the old town; and, bent on discovering a volcano or a nyanza far afield, never wasted time in wandering about the glorious island itself.

On the first day that one leaves the road behind and finds oneself at large in the dense green of Zanzibar's titantic verdure one is conscious of a newness of interest as when one reads for the first time some book of very distinctive imaginative quality.

The woods and fields, the "shambas" (plantations), are like the contents of a Brobdignagian glass house; the colors of flowers and trees themselves are so elementary as to seem like a child's concept of beauty in nature, and when, unexpectedly, without preparation of any kind, the sight of the clove trees, shining green, red-stemmed, symmetrical, stretches before one, with the ultramarine of the Indian Ocean as a background for their

unequaled loveliness, the beauty of the whole writes itself on the memory of the most commonplace of observers as an indelible delight.

The island, about the same size in square miles as Long Island, is of a different shape, being shorter and much broader. It is one of Great Britain's protectorates, but Sayyid Ali bin Hamoud, its present Sultan, has political instinct and a spirit of progress. Since his accession he has materially bettered his position and exalted his dominion in European as well as British eyes.

To the south of the town the landscape is less redundant and riotous in vegetable expression, but goats abound, and find all they need in the way of food to make them marketable.

A TROPICAL PARADISE

But to the north the mango trees, palms, cloves, and every form of orange and lemon crowd thick and glorious under the most primitive of husbandmen. Just as Africa itself is netted over with aimless footpaths, so is Zanzibar veined with little tracks worn deep into the living green so long ago that no tradition follows the feet of those who made them. That black, furtive, futile being whose American enfranchisement convulsed the United States still stands there at the door of his hand-hewn hut like a creature potentially human, but lovable beyond belief in these appropriate surroundings, knowing himself to be but 15 minutes out of the jungle, and as one once said to the writer, who was endeavoring to tell him of the civil war, "happier when he lives near to the leopard and the trail of the things that eat and are eaten than when the shadow of a master's hand is always on his shoulder."

THE OLD SLAVE TRADE

The industrial life of Zanzibar has changed three times since David Livingstone cried for mercy for the black man, who sorely needed it. Under the Arabs the town was a slave center, where the poor creatures, who were caught in the course of one of Tippoo Tib's "war walks" into the interior, were brought to the island carrying ivory, and prepared by various heavy-handed methods for service as slaves in the Persian Gulf or in the shambas and warehouses of Zanzibar itself. The Arabs achieved the best negroes imaginable, whatever their methods may have been, and when England ruined Tippoo Tib by her slave regulations ivory took the place of slaves as a trade staple, and dealers from hither and yon brought their ivory for sale to the quaint Arab town, whose sanitation was then a by-word of the East.

The bodies of dead slaves were frequently put out on the beach by Arabs too inhuman to give them burial, and animals who had died were disposed of in the same fashion. Bath water was informally evicted through harem windows, and all the wanton waste of the cooking department in large Arab houses was banked up by the kitchen doors. There is a tendency to that sort of thing still, but Dr. Spurrier, Zanzibar's health officer, untrained as a sanitary engineer, but essentially scientific and resourceful, has removed Sir Richard Burton's reproachfully apt epithet of filthy in connection with Zanzibar town.

THE CLOVE INDUSTRY A SALVATION

But the third and last phase of industry in Zanzibar has been its salvation, and will keep it alive as a place of importance long after Mombasa has caught up with and passed it as the center for general trade and the entrepôt for the African Hinterland. This last phase is clove cultivation, and the history of the clove in Zanzibar is a record of such pluck and foresight as may well teach a lesson to the proud Saxon who considers his race a monopolist of both qualities.

In 1860 an Arab named Telim bin Isse came up from Mauritius with a handful of cloves in his pockets and 200 plants to put into his shamba. His idea of agriculture was very unique, and he only intended to persevere in clove culture if he could depend on a crop after every neglect and affront had been offered his trees. Their beauty (cloves are a kind of myrtle and exquisite in appearance) excited the interest of Said Burgash, about to become Zanzibar's Sultan, and

812

A FORTUNE IN IVORY. EACH TUSK WORTH $50 TO $100: ZANZIBAR

FIREPROOF VAULT FOR STORAGE OF IVORY, ZANZIBAR

There are 967 tusks in the picture, weighing 58,000 pounds. One of the most remarkable ivory pictures ever taken. Note the addresses stenciled on the uncovered tusks

he wrote at once to the Moluccas to obtain the finest plants which could be bought for money.

Two Dutch ships brought them in an unusually short time, and the Sultan, the most remarkable man Zanzibar has ever produced or associated with its fortunes, sent out numbers of his henchmen to compel laborers from every side to get the plants into the soil immediately. He had read up the whole subject in a book of French authorship, which he had caused to be written out in Arabic, and saw that the enterprise had a great mercantile future for Zanzibar. He knew that the island's supremacy as a trade center would pass, and he hoped to make it with Pemba, the extremely fertile but rather uninteresting island to Zanzibar's north, paramount in the world of spices.

In 1872 a cyclone blew over Zanzibar, which uprooted all the clove trees and blew the cocoanuts flat to the earth without breaking them. Many clove trees were blown into the sea; many were broken off short. Within a week after the storm Said Burgash was rounding up his laborers again and sending hither and yon for plants, which he presented to the poorer Arabs, who had seized on the idea of a crop which could be sold to Europeans, and had put their all into the purchase of plants and slaves for their culture.

THE WORLD'S SUPPLY

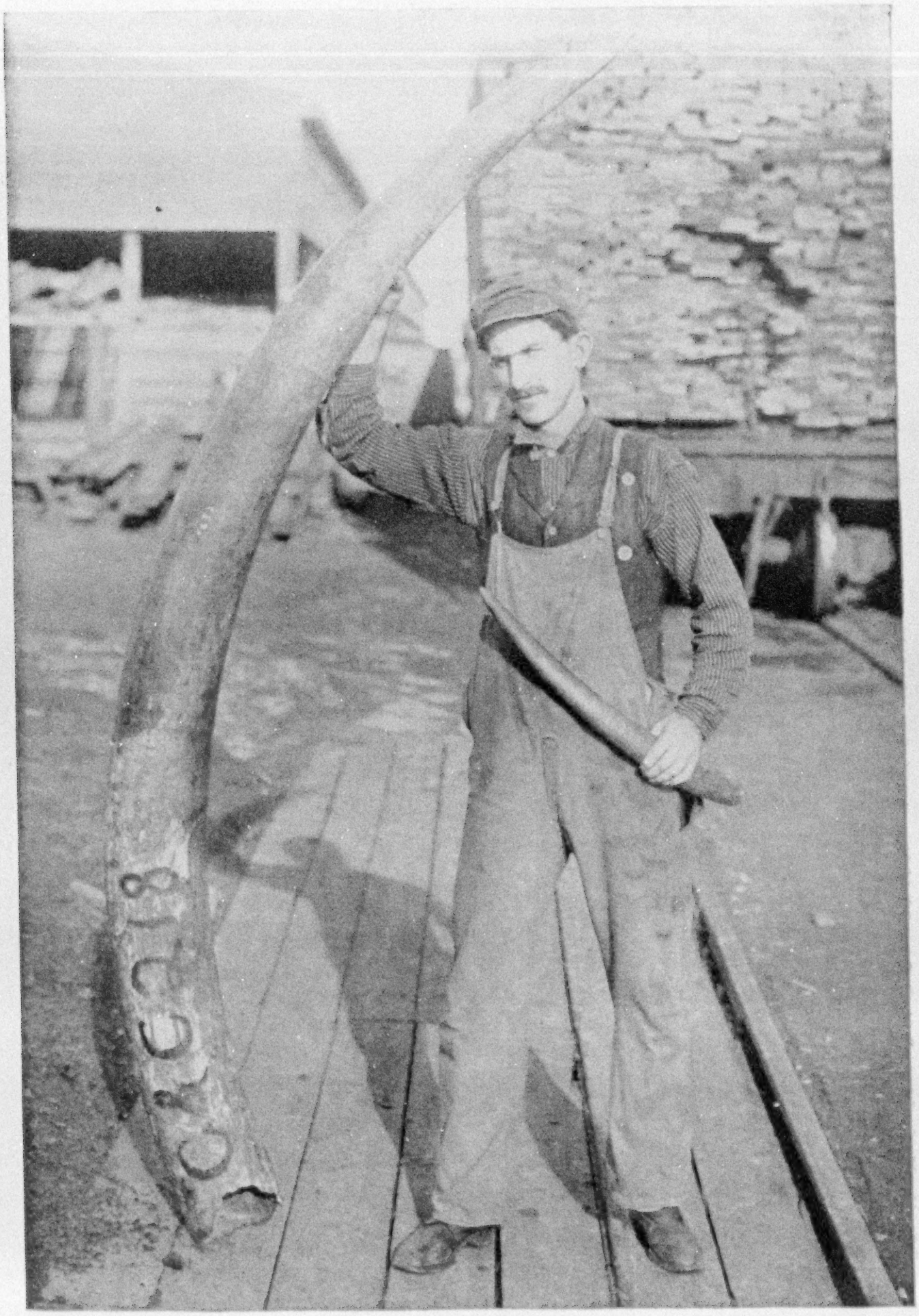
From that second planting comes nine-tenths of the world's clove supply today, and when one realizes that the least output of cloves per annum has amounted (from Zanzibar alone) to 80,000 bales and the greatest output to 200,000, and when one furthermore realizes that the government claims as tax one bag out of each five, one may catch a vista of Burgash's dream, and concede that even the Oriental has in part the greatest of mental attributes—imagination.

One might write a book on Zanzibar, and in the hurry of its beauties and the horrors of its mysterious catastrophes, like the smallpox epidemic or the bubonic plague, forget to tell the half of its wonders. It will always remain in one's mind like a soiled page of the Arabian Nights, with what promised to be a splendid outcome ruined by some fearful visitation of cyclone or of sickness. But the intrinsic strength of the island continues in the clove crop and has attracted an enormous quantity of Indians, who are fast driving out the Arab and keeping up a desultory intercourse with India for caste reasons. The penalty for visiting Zanzibar is the lightest inflicted on any Indian who travels; he is merely required to wash in the Ganges, so that emigration to Africa's east coast is virtually encouraged.

THE MELTING POT

To realize Zanzibar's cosmopolitan quality one must reflect that with the exception of a handful of the Wa-Hadimu, or original people (Bantu) of Zanzibar, no one lives there for any reason except greed of gain or acquiescence to coercion. The Swahili boys are a compromise between the Arab masters and their savage women. One sees Nyassa children black and glossy as lumps of coal, pointing at a distinguished old Arab as their father, or slim young Galla boys, leaning in their coffee-colored perfection over lakes crammed with blue water lilies, claiming kin with an Indian as a parent on one side of the house and a slim Somali on the other. Mohammedanism knits them together in its strong embrace, while only the Indian women secured in the Zenana system remain quite unchanged by travel and the different mode of life which a new country affords.

Much good ivory still comes to Zanzibar, but the world's supply lessens yearly, while the demand for it increases month by month. The best ivory in the world comes from Benadir coast (Italian Somaliland), and as a return American cotton and oil find their way to the Benadir ports—Mogdesho, Barawa, and Merker. For four months of each year these ports are closed, and the "dhows," or sailing ships, which take up case oil and cotton cargo from Zanzibar, together with flour, sugar, and candles, stand stacked in Zanzibar's harbor, waiting for a wind from the north again to promise safety on that sandy treacherous shore of Benadir.



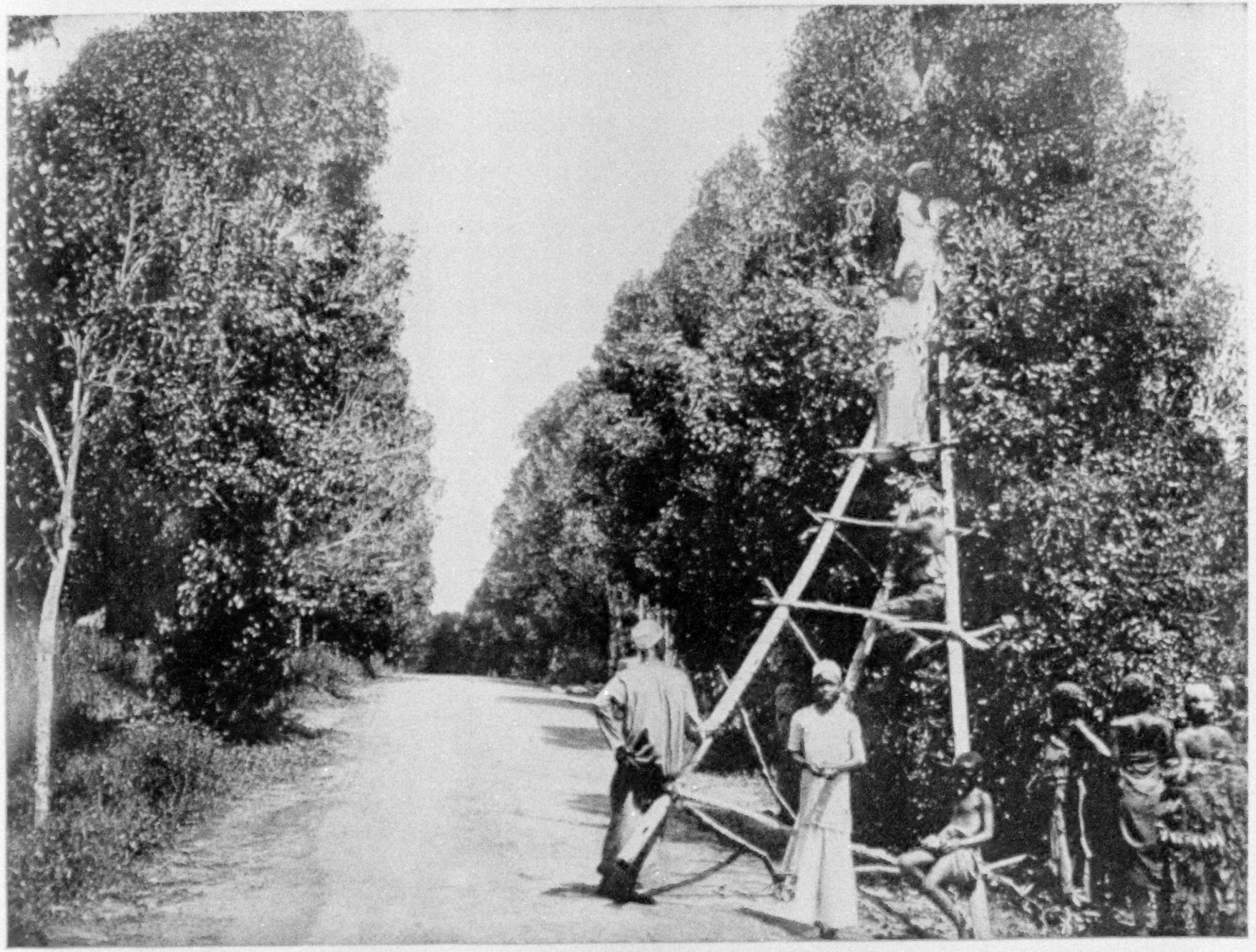
EXTREMES MEET. THIS PICTURE ILLUSTRATES THE WIDE VARIETY IN TUSKS. THE LARGE ONE MEASURES 9 FEET ON THE OUTSIDE CURVE

XUM

A MESSAGE FROM PEMBA SPED IN A NATIVE CATAMARAN

ZANZIBAR'S MAIN STREET, WHERE EACH OF ITS 160,000 INHABITANTS WISHES TO PASS DAILY

XUM



PICKING CLOVES IN ZANZIBAR

The average height of a clove tree (*Caryophyllus aromaticus*) is 26 feet. The natives speak of them with enthusiasm as "towers of green"

XUM

A PLANTATION NEAR ZANZIBAR

UNLOADING A BRITISH STEAMER AT ZANZIBAR

NATIVE MARKET: A COMMENTARY ON ZANZIBAR'S CONSUMPTION OF BANANAS

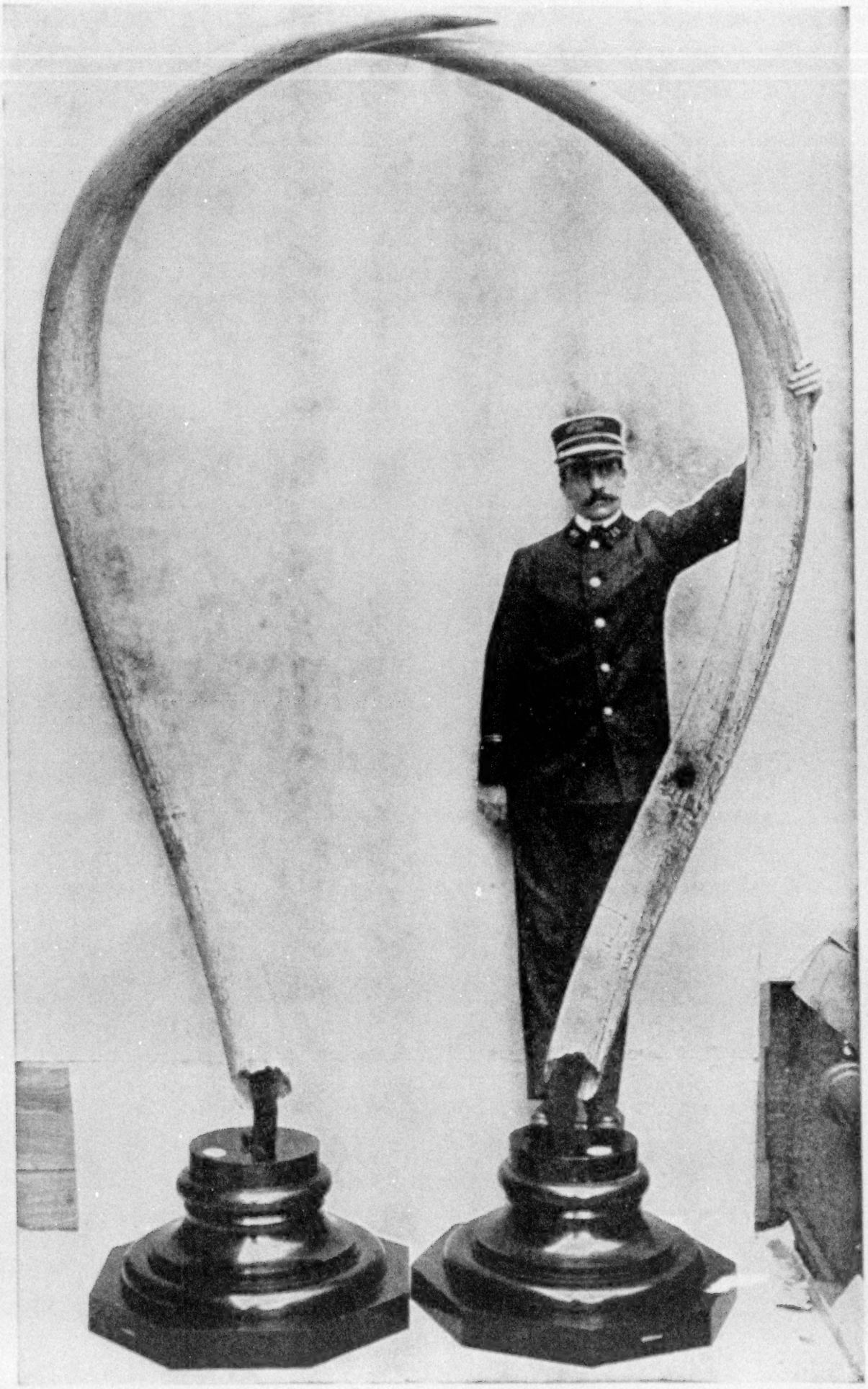
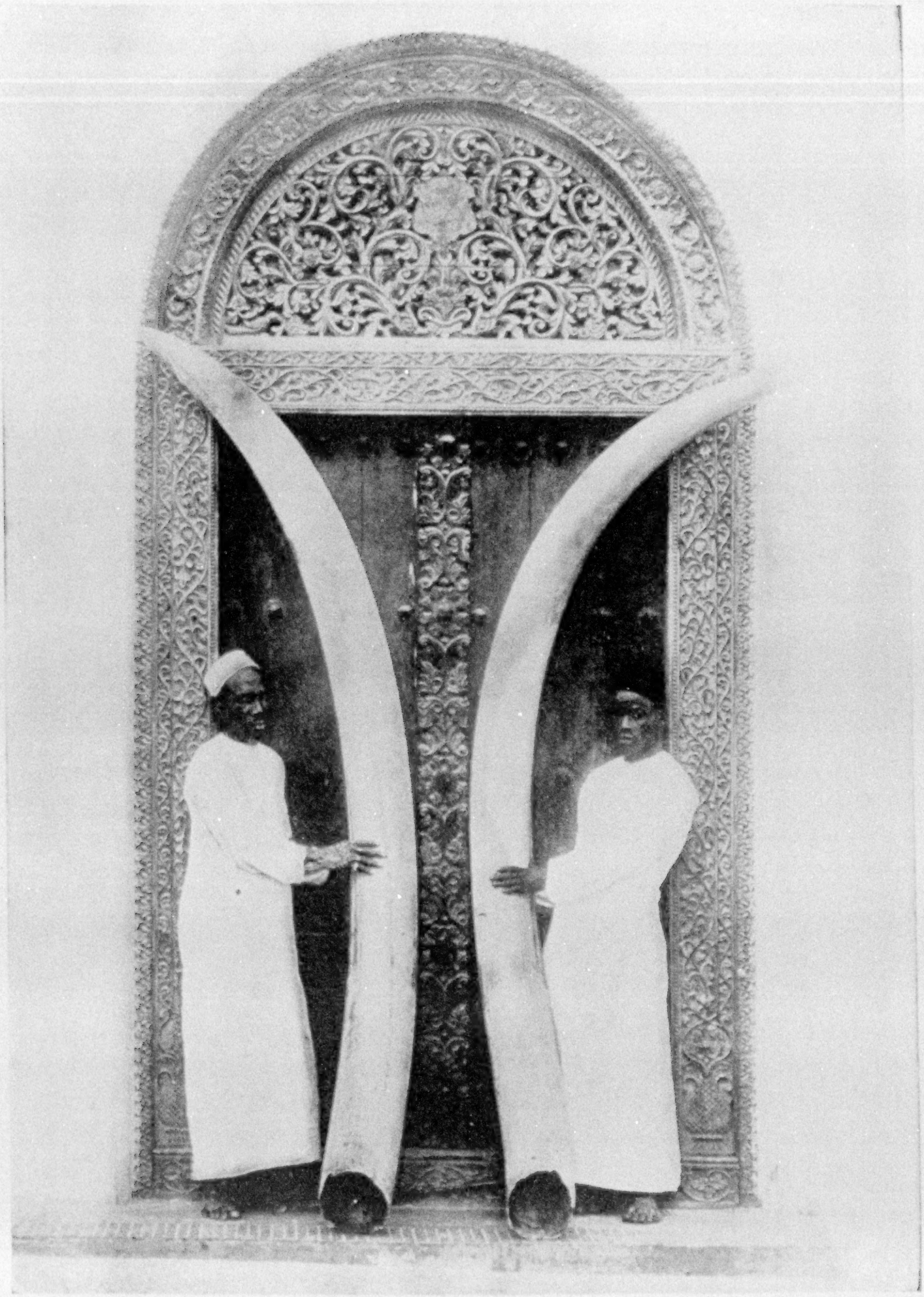


Photo by courtesy of the New York Zoological Park

PROBABLY THE MOST SYMMETRICAL ELEPHANT TUSKS IN THE WORLD



THE TWO LARGEST TUSKS IN THE WORLD; NOW IN THE BRITISH MUSEUM. A TYPICAL ARAB DOOR AT ZANZIBAR, SHOWING THE DELICATE CARVING

INSECT LIFE

The fauna of Zanzibar is meager. In 1873 an hippopotamus dropped in from German East Africa! and whatever exists in the way of wild cat or pig to the north of the island is quite as continental in origin. On a small and neighboring island a very peculiar rodent exists, for which I have never heard even a native name. But the insects of Zanzibar, although rarely venomous, possess a variety that is as extraordinary as their activity. There is the "breaker of saucepans," a green thing, terrible to behold, and an army of ants, in different regimentals, the mosquito in its more harmless phase, and an occasional centipede.

The house-fly is almost unknown.

Zanzibar is perhaps the most interesting town to the negro that the world affords; plenty of old slaves, who haven't seen it for 20 years, dream ceaselessly of it, when a 12-mile walk would bring them to its market-place. And we, who have known European kindness and African quaintness within its far-away borders, turn to our memories of it after months of absence and acknowledge it to be a place of happy dreams.

VOLCANOES OF ALASKA

DURING the first week in June Katmai Volcano, in southwestern Alaska, which had been generally believed to be an extinct volcano, unexpectedly burst into violent eruption and continued active for three days. Vast quantities of dust, pumice, and stones were ejected aloft. So dense was the cloud cast into the heavens that the people in the village of Kadiak, about 100 miles distant, were in total darkness for two days. All the crops on Kadiak Island were destroyed by the ashes; the fish in the sea and in the rivers were killed and all water supplies were poisoned. Through the courtesy of two members of the National Geographic Society, Capt.-Commandant E. P. Bertholf, U. S. R. S., and Mr. W. J. Erskine, of Kadiak, this Magazine publishes a very unusual series of views of the remarkable fall of dust and ashes after the eruption of Mt. Katmai. As all the photographs were taken at least 100 miles from the volcano, the reader can infer the tremendous nature of the cataclysm which could deposit such enormous quantities of dust and ashes so far away.

In the pictures Kadiak and vicinity appear wrapped in a mantle of snow, but the white covering in reality is the white volcanic dust. At the time of year the photographs were taken this region is always as green in vegetation and foliage as any part of the United States. All the land was covered with grasses, plants, and shrubs, whose luxuriant green is buried under the heavy fall of ashes, and a beautiful landscape changed to a scene of desolation.

EXTRACT FROM REPORT OF CAPT. K. W. PERRY, U. S. R. S., ON BOARD THE REVENUE CUTTER "MANNING"

On June 6, 1912, the U. S. R. S. steamer *Manning* lay moored at the wharf at St. Paul, Kadiak Island, taking coal. About 4 p. m., while standing on the dock, I observed a peculiar-looking cloud slowly rising to the southward and westward, and remarked to a friend that it looked like snow. Later distant thunder was heard, and about 5 p. m. I noticed light particles of ashes falling. At 6 o'clock the ashes fell in considerable showers, these gradually increasing. The cloud bank had spread past the zenith when I observed another bank to the northward, and the two met about 30 degrees above the northern and eastern horizon. Thunder and lightning had become frequent at 7 o'clock, very intense at times, and though lacking two hours of sunset a black night had settled down. It was impossible, owing to electrical conditions, to use the wireless apparatus; consequently no information could be sent out. This was also found to be true of the Woody Island naval wireless station. Specimens of the deposit were

FRAME STRUCTURE CRUSHED BY WEIGHT OF ASHES

taken at various times and it was found to consist of dust and fine sand or granules. At 12 midnight the thunder and lightning diminished, but it continued intermittently until the storm (if this term may be used) ceased, on June 8.

The morning of the 7th dawned with volcanic matter falling, and it continued, although gradually diminishing until 9.10 a. m., when it ceased. We then believed that the eruption was over. All of this time no one knew where the eruption had occurred, for, owing to the excessive static, no work could be done by the wireless. About five inches of ashes had formed, and all streams and wells were fouled and choked, so water was furnished the inhabitants of St. Paul by the *Manning* and by the schooner *Metha Nelson*, anchored near by.

At noon ashes commenced to fall again, steadily increasing in density until at 1 p. m. it was impossible to see beyond a distance of 50 feet. At 2 p. m. pitch darkness had set in, heavily static disturbances were observed, and our wireless was dumb. All ashes of the previous day had been removed, yet decks, masts, and yards were again heavily laden, as were also the ship's boats. The ashes now were fine dust and flakes of a yellowish color. Sulphurous fumes were at times in the air, and many thought and spoke of the destruction of Pompeii. Avalanches of ashes on the neighboring hills could be heard, and these sent forth clouds of suffocating dust. Men often collided in working about the decks, the feeble glow of the electric lights and lanterns failing to dispel the awful darkness. The crew kept constantly at work with shovels, and streams of water from the fire mains were playing incessantly on the deck in what at times seemed a vain effort to clear the ship of its deadly burden. The bells of the Greek church in the near-by village boomed out in the blackness, and there were few if any of its followers who did not grope their way to the call to prayer. I might state at this point that I believe the catastrophe appeared more terrible at St. Paul than at the near-by settlements, because of the suffocating clouds of volcanic débris that swept down from the hills close to the town, adding to the fall from above.

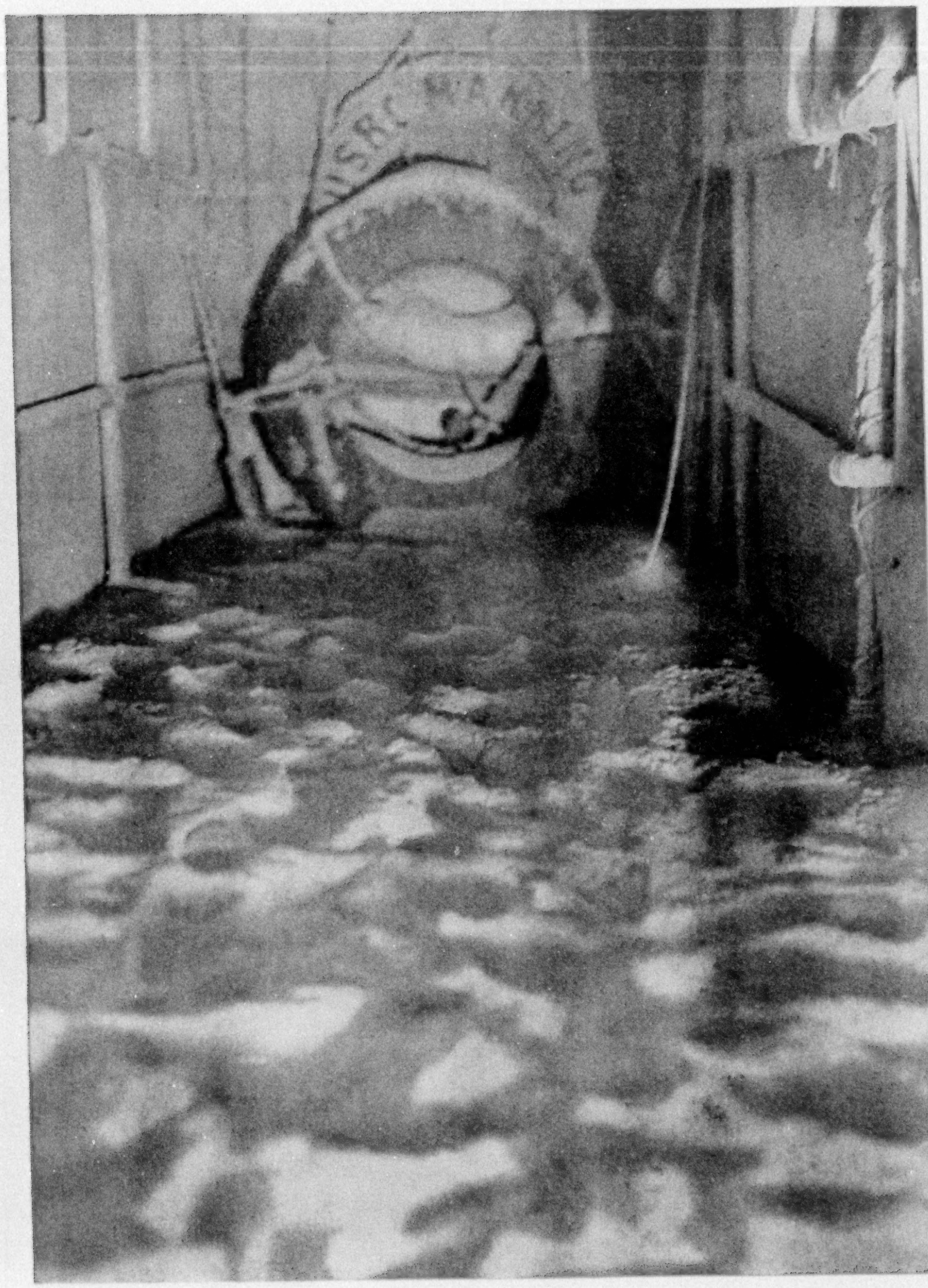
At 10 a. m. the people of the village had sought shelter in the warehouse on the wharf and on the *Manning*—about 835 souls—and others were added later from vessels, the salmon cannery, and the people of Woody Island.

Shortly before 11 a. m. Lieut. W. K. Thompson, of the *Manning*, informed me that several men were cut off in the cannery about one-half mile distant below our dock. He stated that he had a

Photo by W. J. Erskine

VIEW OF KADIAK, SHOWING VOLCANIC ASH

The depth in the foreground is about 12 feet. The lake in the center of the picture is completely filled. June 14, 1912



ON THE "MANNING'S" BRIDGE

The decks of the *Manning* were repeatedly cleared of dust and ashes, but a few hours would bring about the same condition. Note the effect of drifted snow

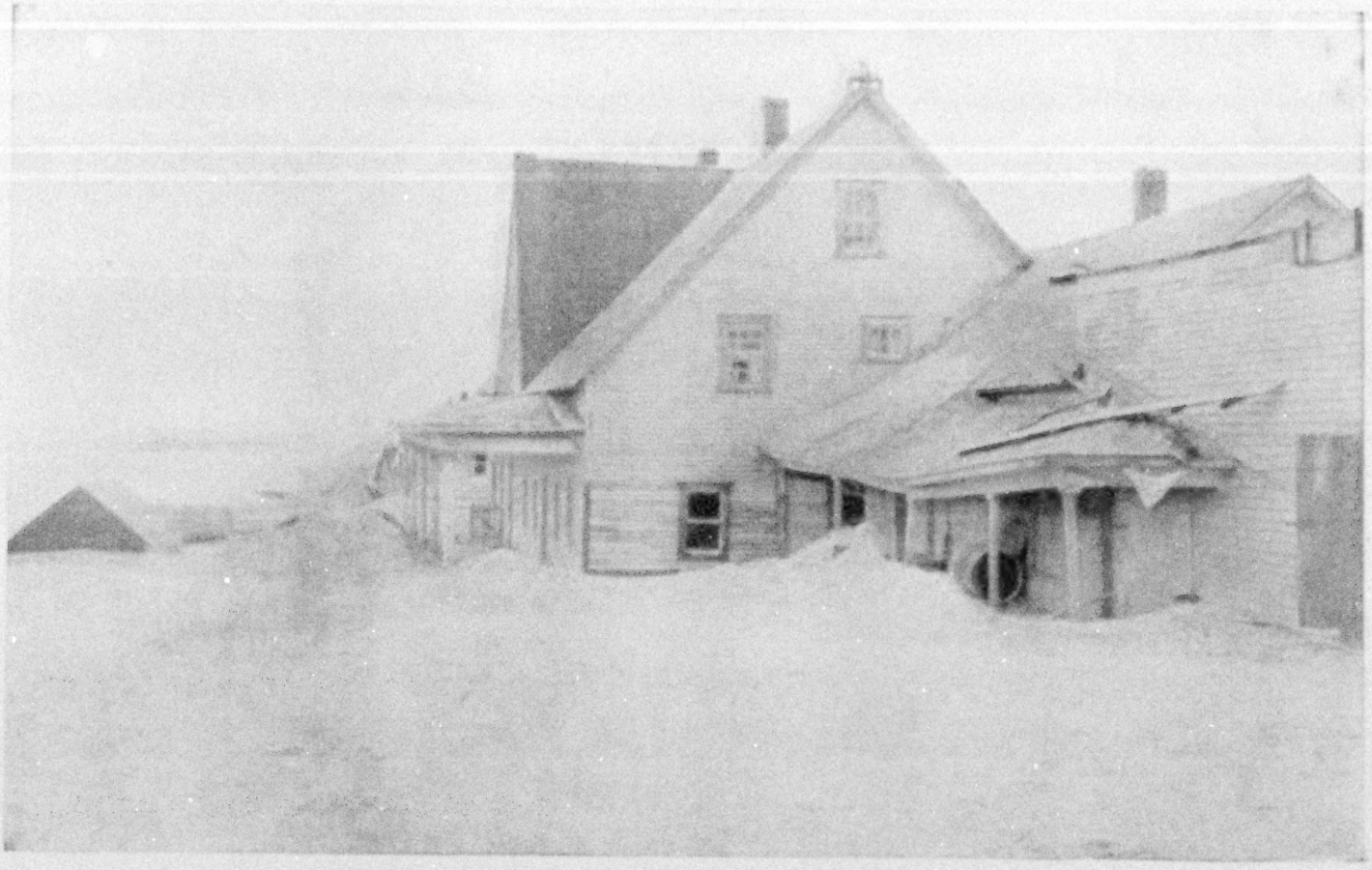


Photo by W. J. Erskine

THE A. C. COMPANY DWELLING-HOUSE AT KADIAK

Porch broken down from weight of ashes. The deposit here was 24 inches thick on the level. June 14, 1912

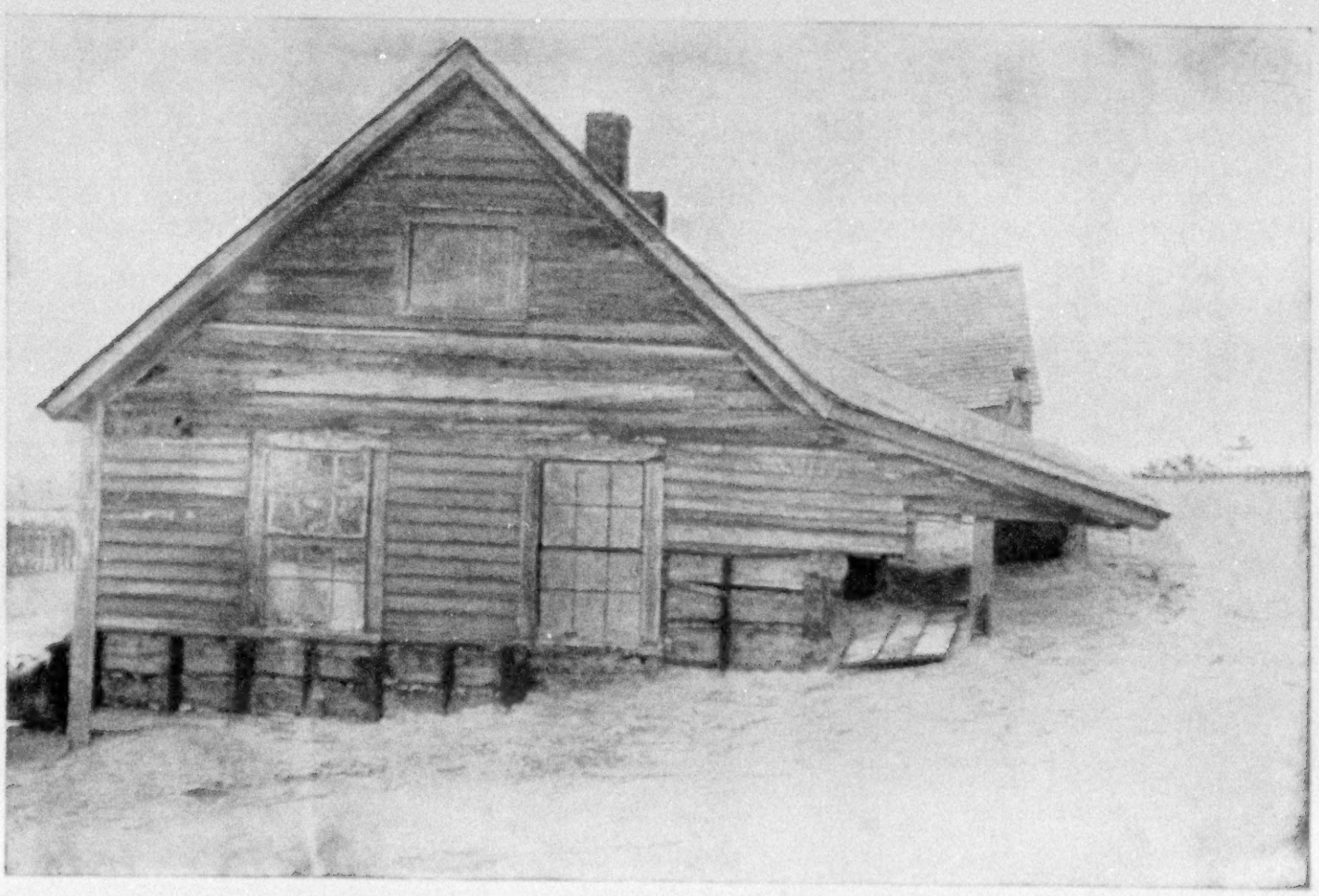


Photo by W. J. Erskine

RESIDENCE AT KADIAK MADE UNINHABITABLE BY THE FALL OF ASHES

A slide wrecked the rear of this house and the living rooms drifted half full. Note the line showing the level of the ashes in the window to the left. June 14, 1912

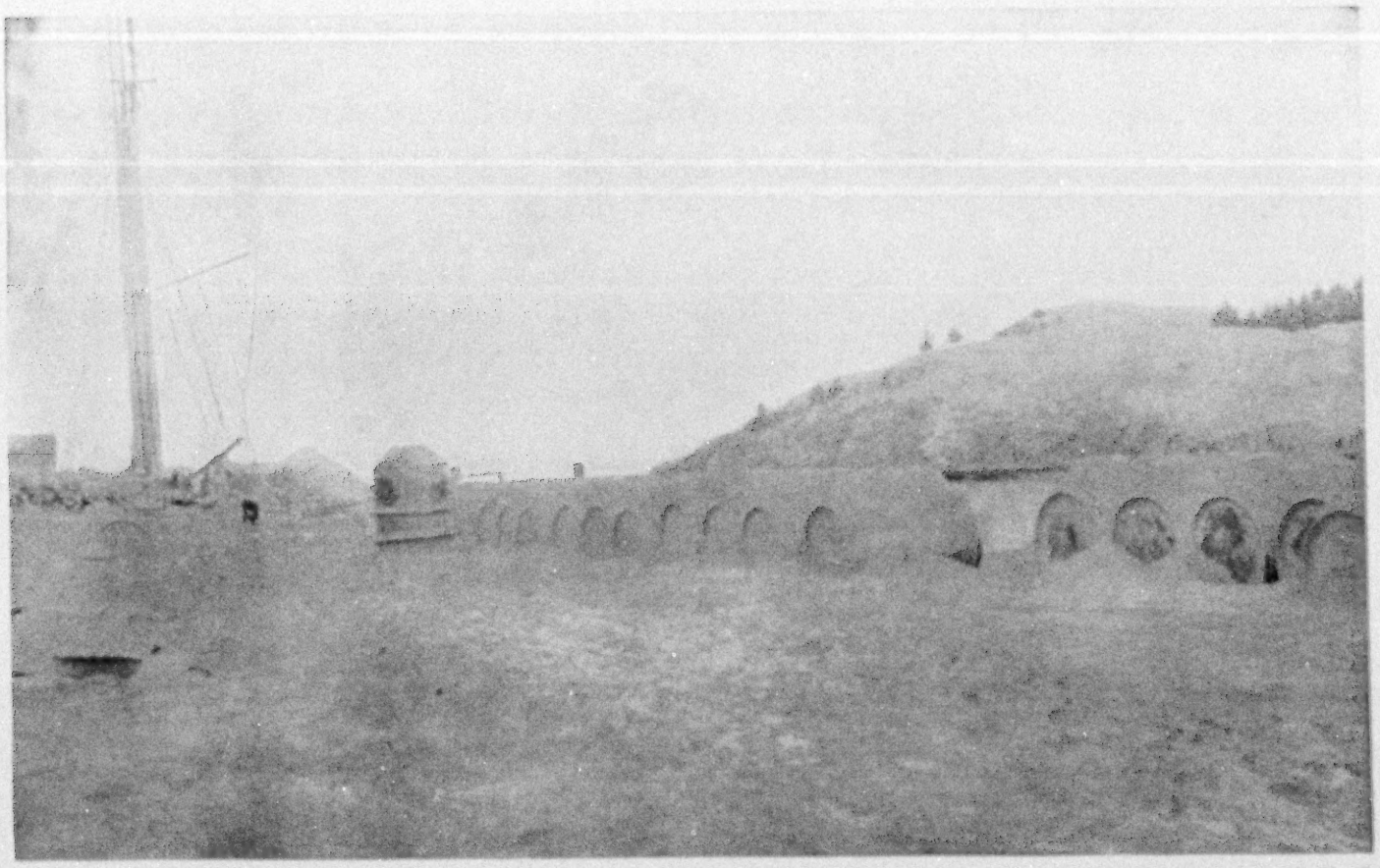


Photo by Lieut. J. F. Hahn, U. S. R. S.

THE DOCK AT ST. PAUL, ON KADIAK ISLAND, SHOWING THE HEAVY FALL OF ASHES

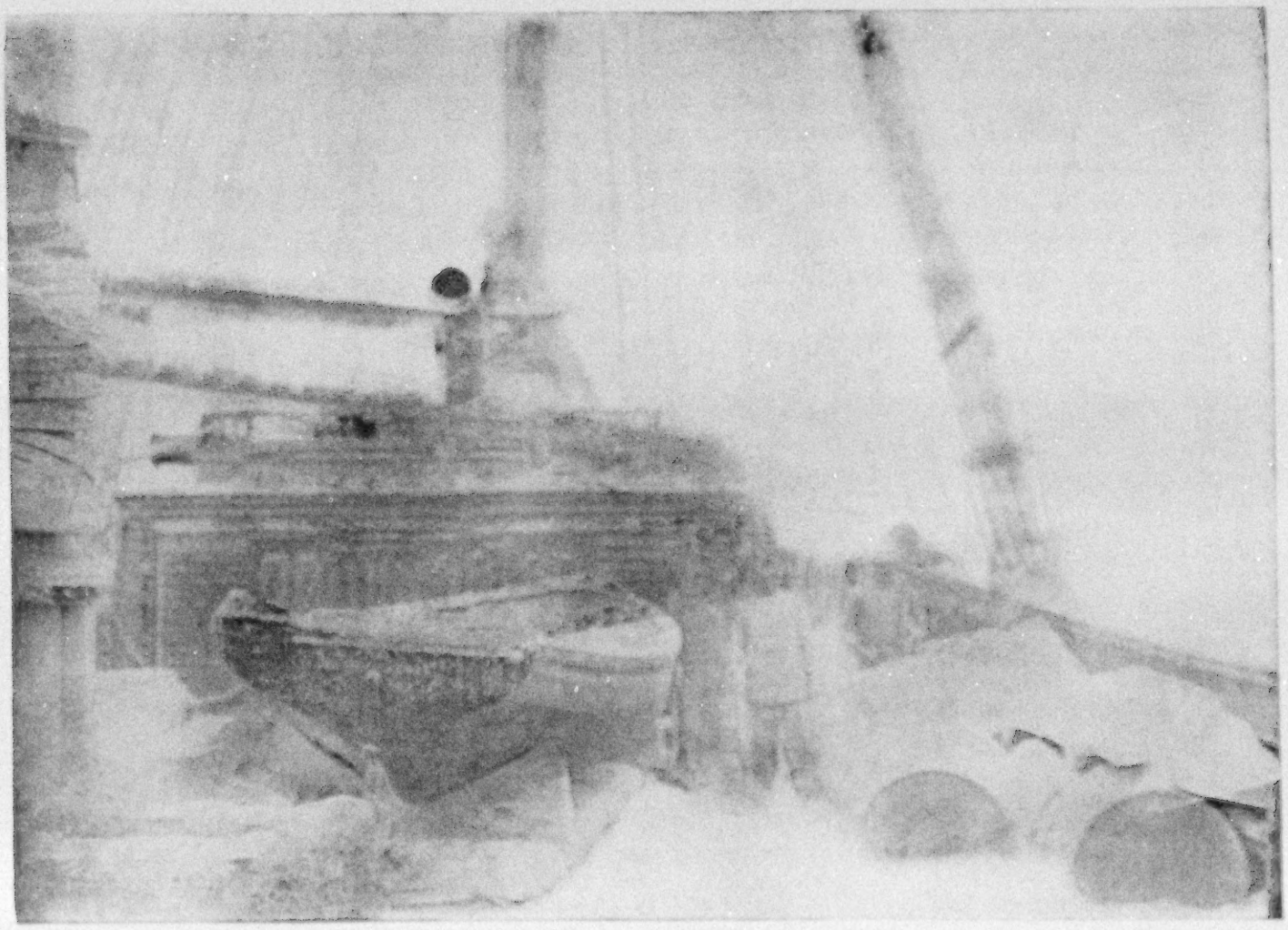
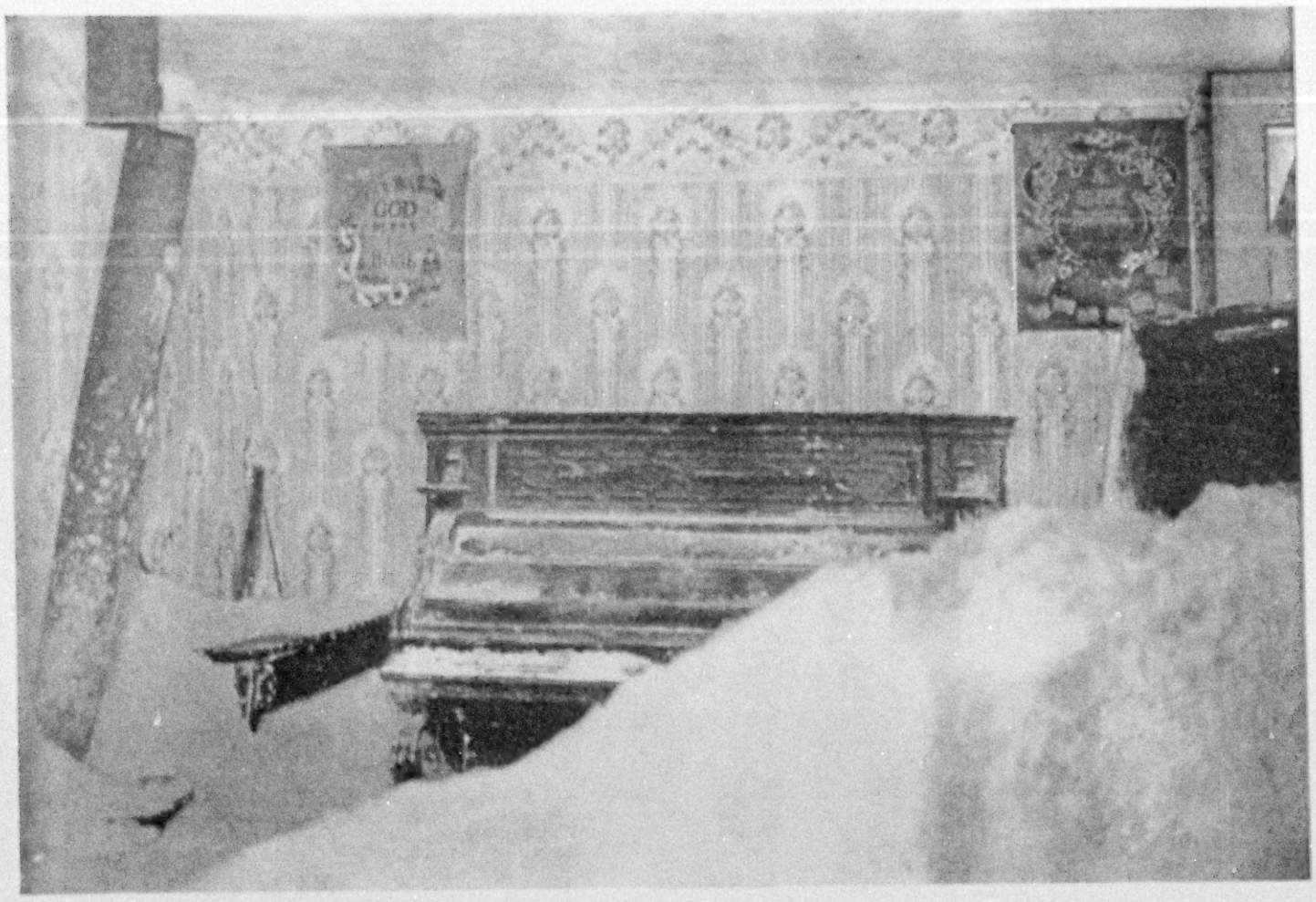


Photo by W. J. Erskine

ON BOARD THE "METHA NELSON" AT KADIAK

Ashes were still falling slightly when this was taken. The deposit here shown nearly all fell the last day of the disturbance; the fall of the first day had been fairly well cleared off. June 9, 1912

XUM



HOUSE AT KADIAK RUINED BY AVALANCHE OF ASHES FROM HILLSIDE

Weight of ashes from hillside avalanche crushed in roof and almost filled the interior of this house. St. Paul, Kadiak, June 9, 1912

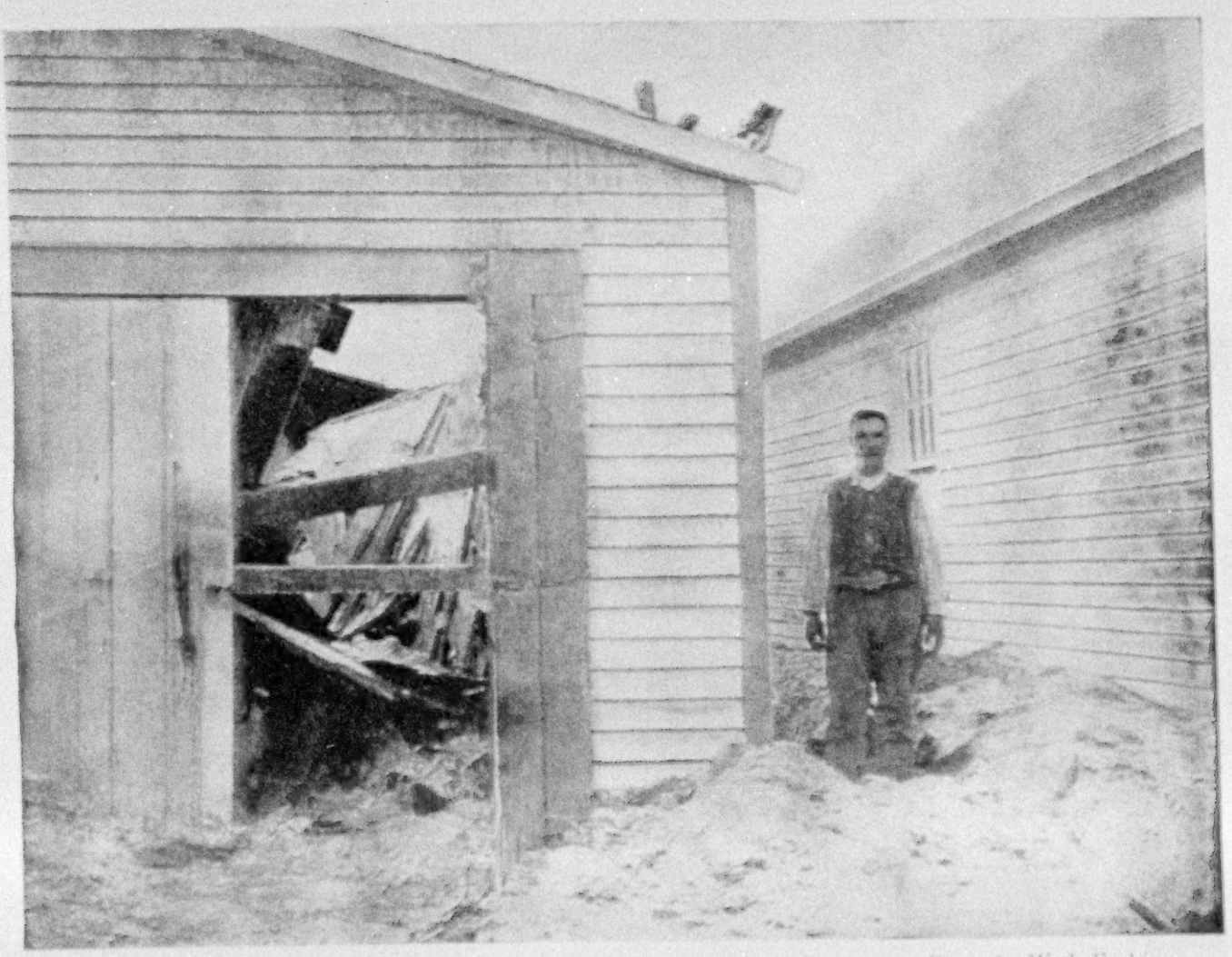


Photo by W. J. Erskine

SHOWING ROOF OF FISH HOUSE AT KADIAK BROKEN DOWN FROM WEIGHT OF ASHES, JUNE 14, 1912

Photo by Lieut. J. F. Hahn, U. S. R. S.

VOLCANIC DUST 2 FEET DEEP: SCENE AT KADIAK AFTER THE ERUPTION OF KATMAI VOLCANO

party willing to try a rescue and asked for orders. I replied that I dared not give him orders, for it might be sending men to death, but that he and his party had my permission to make the attempt. The party at once decided to go, departing at 11 o'clock, and returned on board with the rescued men at 1.30 p. m. It was an heroic act deserving of highest commendation.

At 2.30 p. m., June 8, the fall of ashes decreased, the skies assumed a reddish color, and finally objects became dimly visible. All clothed and festooned in ashes, nothing looked familiar, and as frequent seismic disturbances were still felt, much fear existed that worse was still to come.

The night of the 8th was spent in suspense, but when the morning of the 9th dawned and all precipitation of ashes had ceased, it was felt that the eruption was over. Some time during the eruption the wireless station at Woody Island was destroyed by fire, doubtless caused by lightning.

June 12 a message reached me from Lieutenant Thompson, in charge of the *Redondo* expedition, advising that he had been in the vicinity of the volcano, which was Mt. Katmai, on the mainland across the Shelikof Strait.

During the 9th, 10th, and 11th the appearance of the skies seemed to indicate that some substance was held in suspension, and at times most unpleasant and strangling gases filled the air, making it difficult to breathe.

The outlook for the future of this vicinity is at present a problem. While the fish are now very scarce, it is generally believed that they will return. Many gardens have been uncovered, but I doubt if they produce much this season, and their product will be greatly missed by the natives. Cattle are finding a little feed on the hillsides, where the deposits slid down, but all the feed is impregnated with sand and ashes.

The officers and crew of the *Manning* rendered gallant and unflinching service through an ordeal that was arduous and

Photo by Lieut. J. F. Hahn, U. S. R. S.

REFUGEES FROM KADIAK ON BOARD THE "MANNING"

terrorizing beyond description, and I cannot refrain from paying the highest compliment to many of the inhabitants of Kadiak, who by their courage and forgetfulness of self in this time of peril coöperated with us in every way in giving help to the weak and suffering.

Katmai Volcano is one of the long belt of active and extinct Alaskan volcanoes which extend for 1,600 miles from Kenai Peninsula, along the Alaskan Peninsula and Aleutian Islands. No less than 60 active or recently active volcanoes are already known, and this number will probably be increased when the territory has been more thoroughly examined. The belt includes Mt. Wrangell, whose huge dome reaches 14,000 feet elevation; Mt. Shishaldin, a most graceful peak, whose outlines rival Fujiyama, and Bogoslof, whose suddenly appearing and as suddenly disappearing islands have startled mariners for the past 100 years.

Immediately after the eruption the National Geographic Society, in coöperation with the U. S. Geological Survey, sent Mr. George C. Martin, a geologist of the Survey, to Alaska to make a reconnaissance of Mt. Katmai and neighboring volcanoes. Mr. Martin has been in the field of volcanic disturbance throughout the summer. His studies are preliminary to an extended investigation of the Alaskan volcanoes, which the National Geographic Society will inaugurate in 1913.

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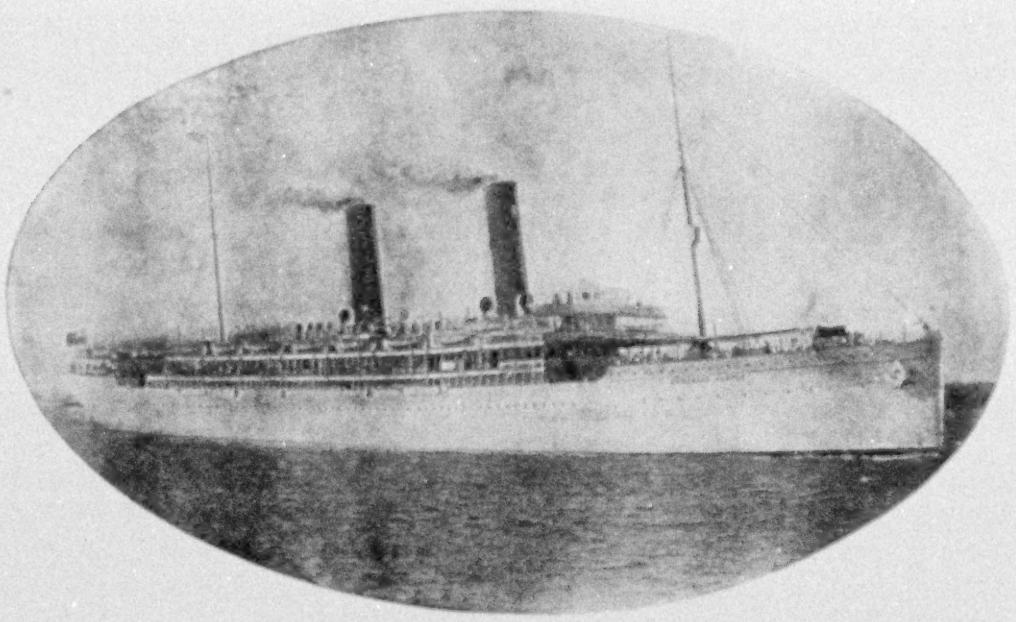

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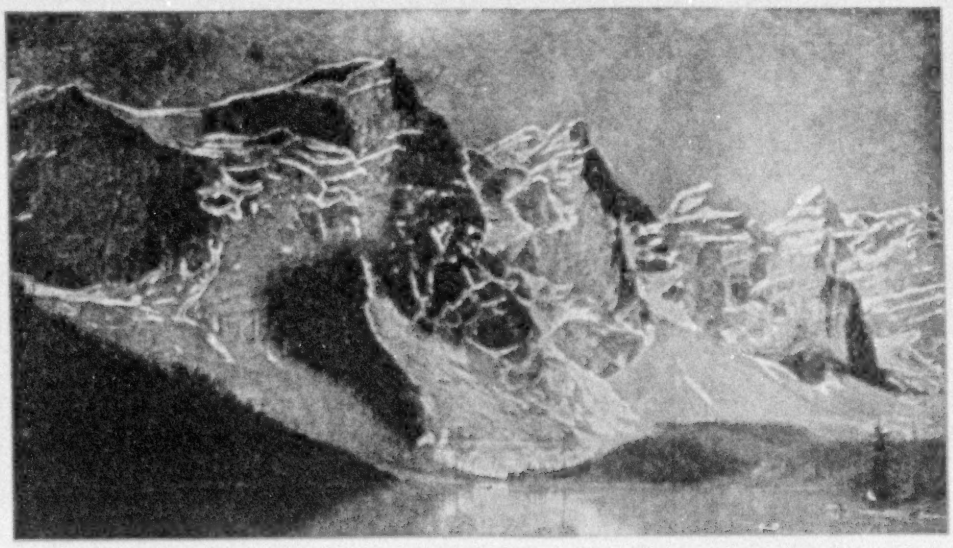

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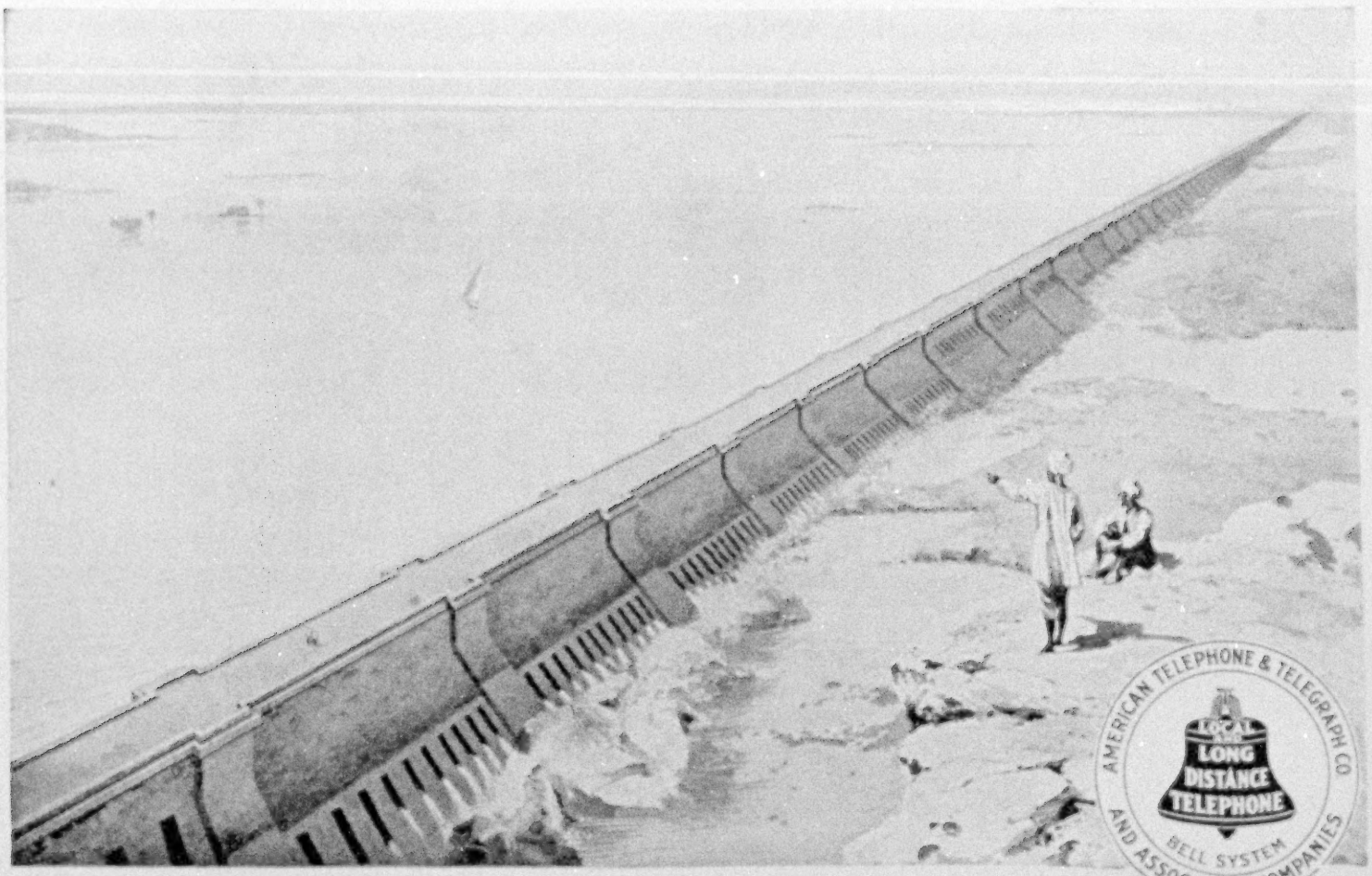

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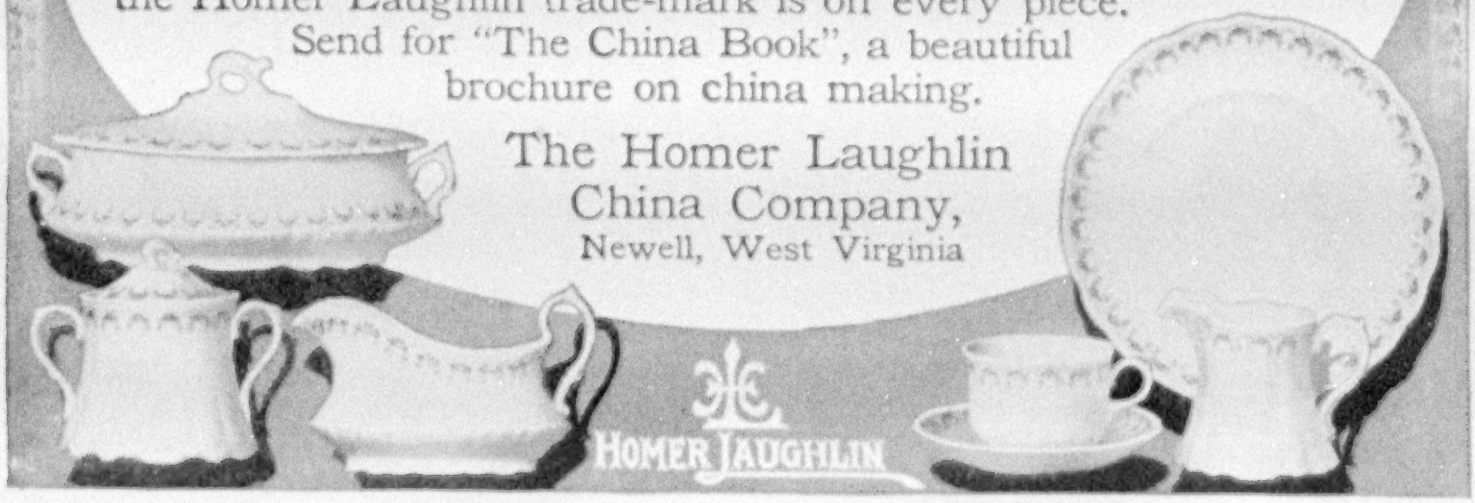

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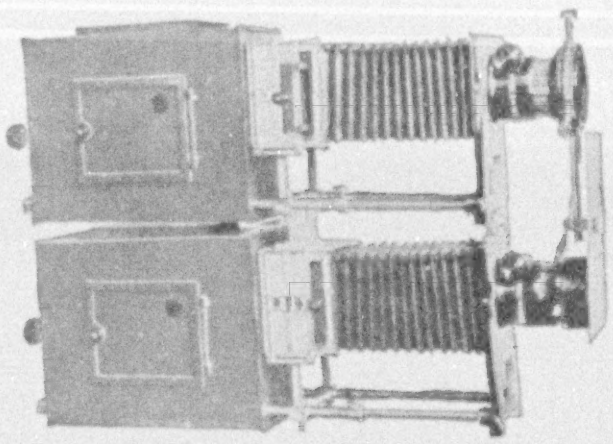

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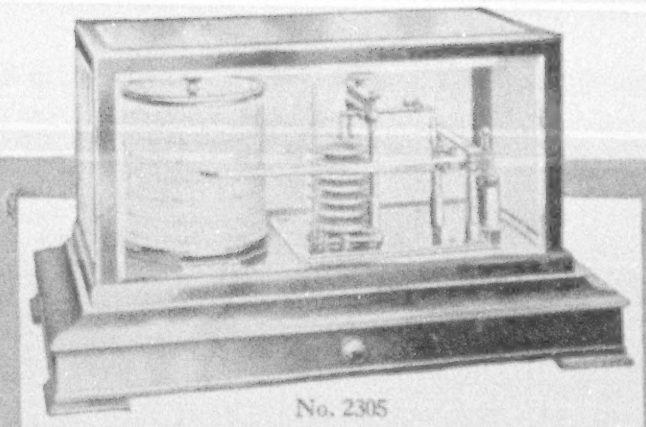

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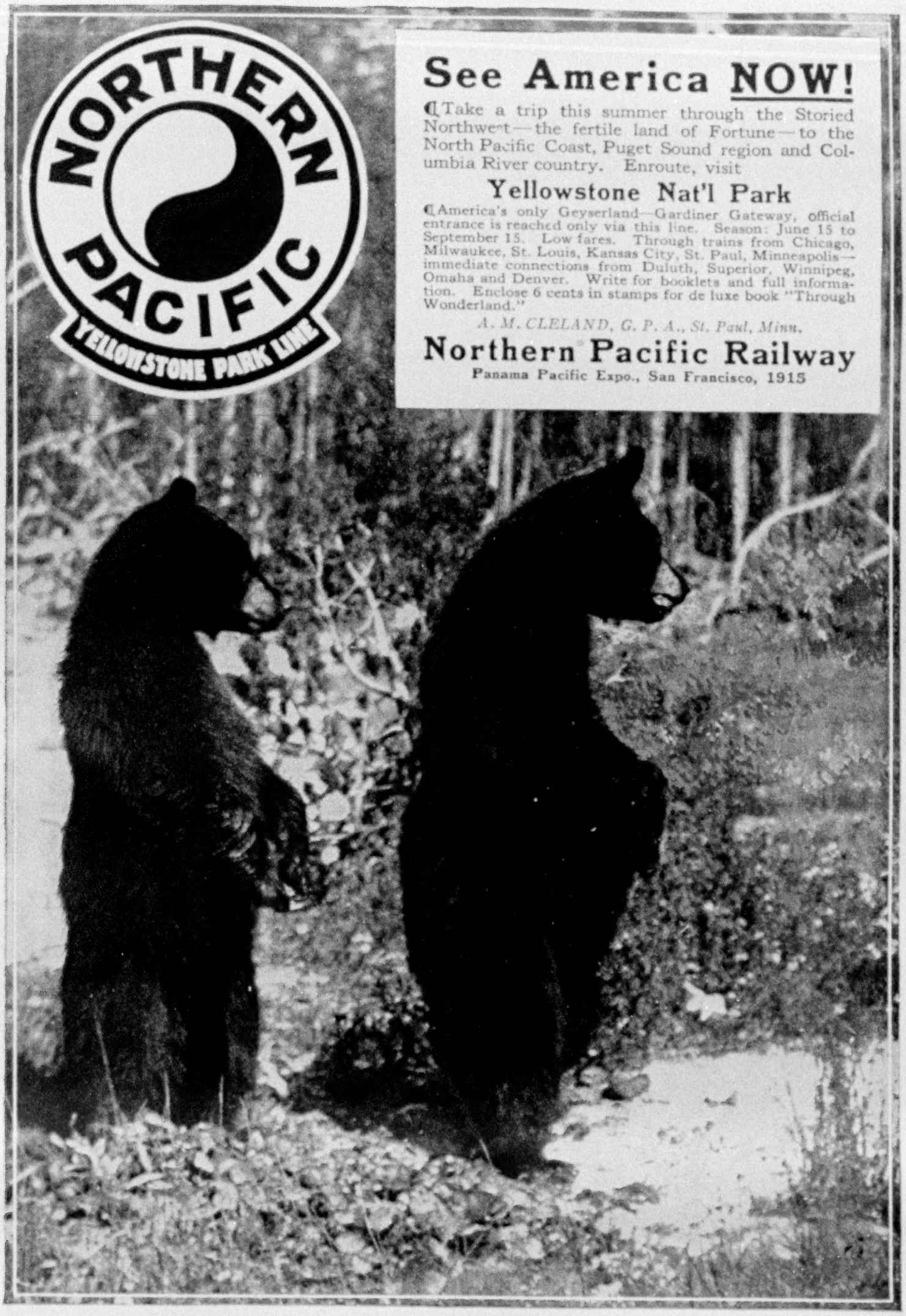

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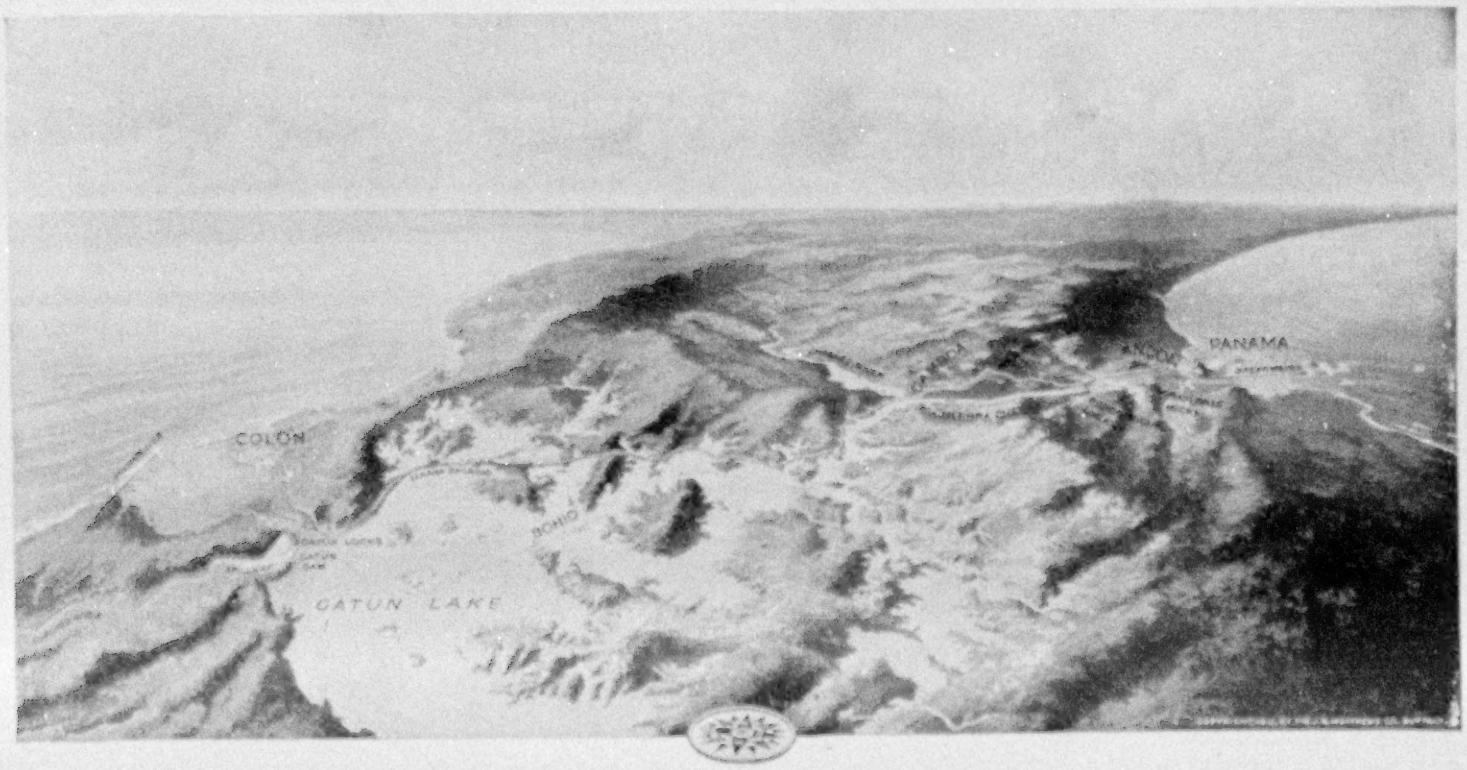

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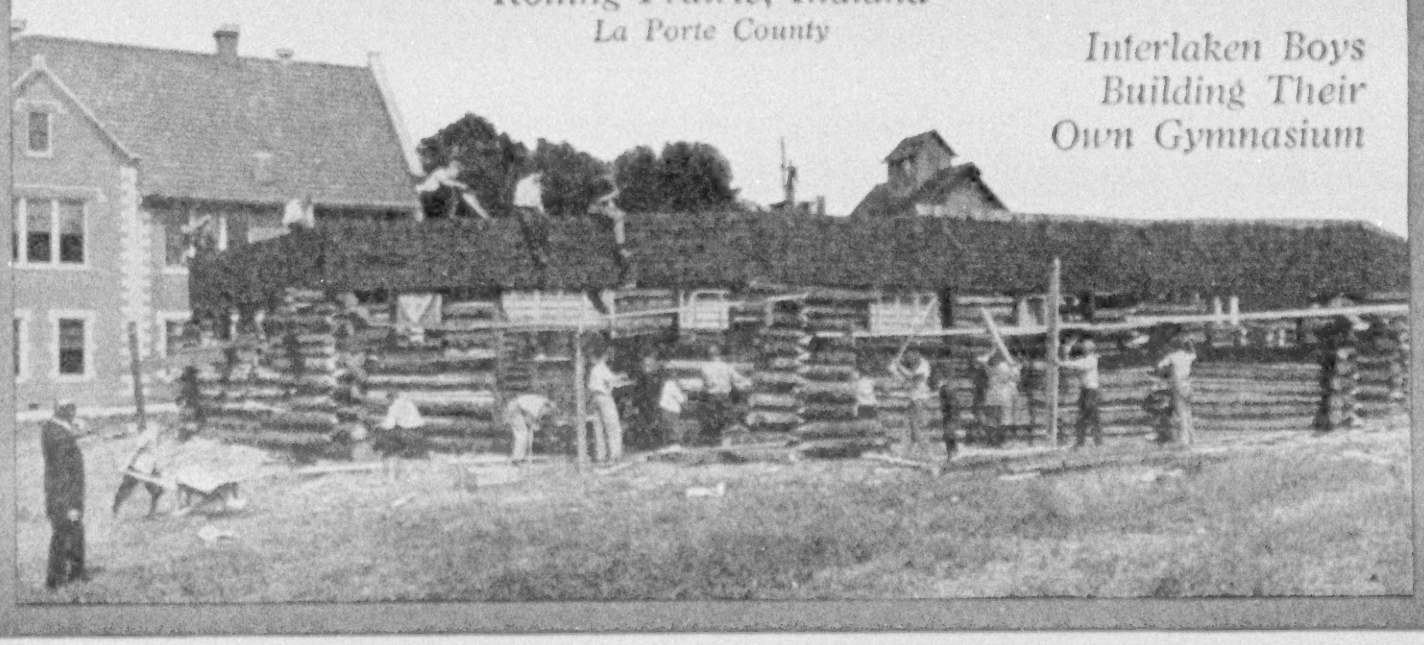

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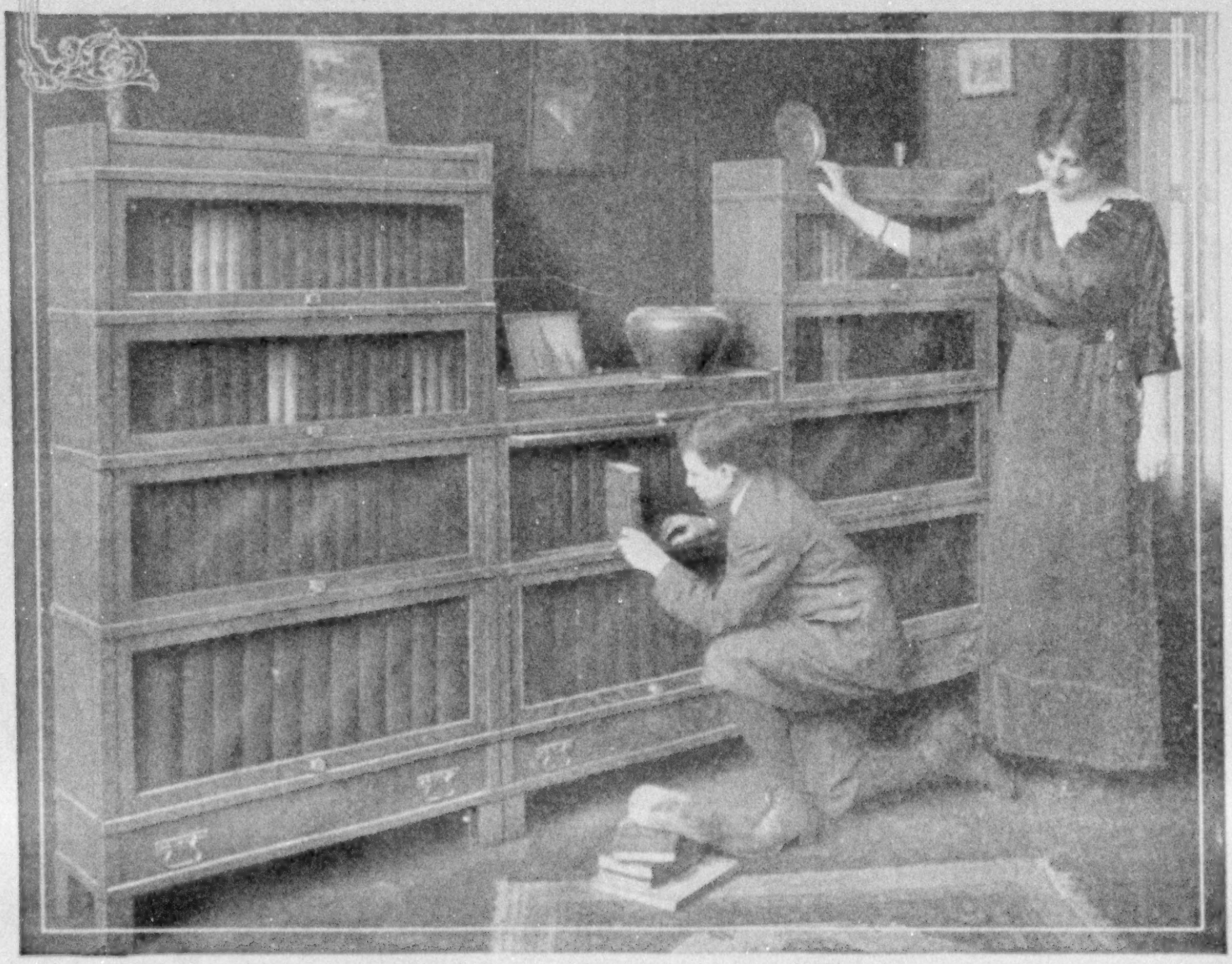

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